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Biology of Ourselves

A Study of Human Biology

Gordon S. Berry and Harold S. Gopaul



Teacher's Manual



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Port Moody Senior Secondary School

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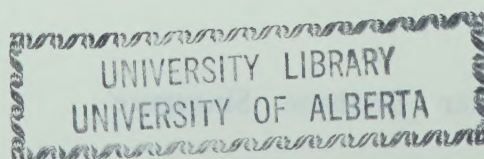


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Introduction

This manual has been compiled primarily in an attempt to help teachers who have had limited teaching experience or who have not previously taught classes in human biology. We hope the manual will also be useful to experienced teachers, by increasing their inventory of classroom activities and by serving as a useful resource for developing new approaches and techniques.

Topics in human biology have an inherent personal motivation that stimulates student interest to a greater degree than survey biology courses. Many senior courses in biology are so wide in scope, including such important topics as botany, genetics, biochemistry, etc., that there is insufficient time to deal adequately with the human body. Because of its importance for life skills and relevance to daily living, human biology is deserving of a place of its own in the curriculum.

The materials and approach used in this text were developed over a period of more than twelve years, during an introductory and developmental period when the needs and demands of students were recognized and attempts were made to satisfy the demands they made for knowledge about their own bodies.

Biology of Ourselves is organized as a systems approach to the human body. These systems have been grouped under general headings and a number of other topics have been included. These additional topics are not usually in human biology texts, but they are considered to be of special contemporary importance by the authors. The topics include disease agents, diet and weight control, smoking, alcohol, drugs, and genetics. Such topics add relevance to the structure and function of the body organs and provide a medium through which students can ask questions that are important to them in making decisions about their own lives.

Each chapter of the text is supported by activities that investigate some of the concepts in the chapter. These activities may be used in a discovery approach or for the support and consolidation of material already taught and developed; other activities simply provide interest and motivational value. The activities should be an integral part of the course and their value cannot be overemphasized.

The text provides more material and a far wider scope than can be used in any one class or course. Teachers must give serious thought to what they will or will not include in the course curriculum.

To help teachers choose the topics most useful for their specific course or class, this manual provides the following items for each chapter:

1. a summary of the main points covered in the chapter, called "Chapter Focus",
2. objectives,
3. a chart listing "Topic Priorities",
4. general teaching suggestions for the whole chapter and specific preparation tips for activities.

For each chapter, teachers are also provided with some or all of the following:

- supplementary activities,
- multiple choice questions on chapter content ("Self-Tests"),
- crossword puzzles,
- diagrams for students to label,
- special handouts,
- additional resource materials.

Finally the intent of this text is to motivate and interest students about how their own bodies work. The text is predicated on a healthy view of the

body and the development of a positive approach to the way the body is used. It attempts to explain the delicate balance in which the body is held and how important it is to avoid abuse of its systems. It also recognizes the human qualities of this specific study of biology and that these qualities extend beyond the study of structure and function.

Gordon S. Berry
Harold S. Gopaul
December 1982

STUDENT NEEDS

In designing and teaching a course in human biology, the expectations and needs of many persons must be considered, although in the last analysis it is the needs of the student, of course, that are paramount. The community expects the school to provide experiences that will produce individuals who are responsible members of society. University and college faculty members expect beginning students to have reached a certain standard of biological literacy. Parents, superintendents, and principals all have their expectations. Thus, pressures will be brought to bear on the teacher to respond to these differing expectations.

The teacher, with skills in pedagogy and in biology, will seek to teach a course which serves as a vehicle for stimulating learning, provides opportunities for investigation and satisfying student curiosity, gives relevance to the topic, and provides opportunities for students to experience success.

Students will have many reasons for taking a course in human biology, focussed by their personal goals, ambitions, and interests.

It is worth trying to identify some of the ways in which the teacher, through the medium of this course, can respond positively to student needs and the expectations of others in society, identified as important by the teacher. These can be usefully grouped under three headings: attitudes, skills, and knowledge.

1. HELPING TO DEVELOP ATTITUDES

SELF-WORTH. Students need to build their concept of self-worth and recognize themselves as unique. They must be treated as individuals with their own sets of values, talents, and interests. They need experiences that will build this concept and reinforce their pride in themselves.

RESPECT AND SENSITIVITY FOR LIFE. Human biology provides an excellent vehicle for encouraging sympathy and understanding of the problems of others: physical disabilities, mental problems, and other problems. It provides an opportunity to foster respect for others and to recognize the struggle for existence that characterizes the activities of all living things.

AN OPEN MIND. This course should serve to develop attitudes toward positive research and new ideas that may be at variance with previous knowledge. Students require practice in critical analysis of information, and advertising and product labels. They need to be shown that there is often more than one

answer to a question and that phenomena may have several possible explanations.

CO-OPERATION. This is an on-going objective in all classroom teaching, and one that is readily encouraged in group work and experiments in a human biology course.

RESPONSIBILITY. The course must provide opportunities for students to display initiative, to make responsible decisions, to work independently, to be trusted, and to be allowed to take responsibility for their actions. The teacher has a responsibility to increase the student's environmental awareness and to provide scientific literacy in the way in which the environment in which we live is constantly being threatened with adverse consequences upon humans and all living things.

FOSTERING CURIOSITY. It is not enough to supply knowledge. If education is to be a life-long process, the atmosphere for asking questions must be carefully prepared. Student curiosity about themselves, the past, and future must be constantly uncovered and given the opportunity to develop.

2. SKILL DEVELOPMENT

Some skills, such as dissection skills, are specifically related to biology, but others have value in many other areas.

COMMUNICATION SKILLS

SPEAKING AND LISTENING. As many of the topics studied in human biology allow students to relate personal experiences or knowledge of events that have taken place within the family, there is ample opportunity for both talking and listening and to foster both of these skills.

READING, WRITING, AND RECORDING. Such skills are fundamental to all disciplines. Biology is no exception. Students should be provided with opportunities to give written and oral reports that require research. Data must be recorded accurately in words, diagrams, graphs, and tables with attention to vocabulary, spelling, presentation, drawing, and detail.

IMPROVEMENT OF VOCABULARY. Students must build an appropriate vocabulary of relevant terms in order to communicate well with others. Skill in the use of a glossary to improve their range of terminology is valuable.

LIBRARY RESEARCH. The course should provide an opportunity to research topics of special interest to the student in more depth.

MANIPULATIVE AND DISSECTION SKILLS. Students should be familiar with the use of all standard laboratory equipment with appropriate instruction in safety techniques. Accurate, careful work should be expected and precise observation and recording of results maintained.

THE MICROSCOPE. This tool is such an important extension of our senses and so fundamental to the understanding of the basic cell concept, that it requires a special place in the biology student's armoury of skills.

REPORTING. The research and reporting of information in written, oral, and graphic reports should be encouraged. The use of professional reports from magazines, newspapers, and other media is a useful and interesting way to augment learning, to update information and to aid students in gaining confidence.

PLANNING AND EXPERIMENTAL DESIGN - PROBLEM SOLVING. Many experiments undertaken in the school laboratory call for following instructions in the manner of a recipe. Students must be given some opportunities to plan, design and develop small research ideas of their own to form hypotheses, and to predict and to extrapolate. They should practice analysis by determining the validity of the data they achieve so that the scientific method with its control of variables and comparison controls becomes a natural part of the student's thinking.

3. KNOWLEDGE OF CONTENT

Students will have had exposure to many of the topics developed in this course in their grade nine science studies or other health courses. Many parts of the course will be understood in a superficial way from their own experience or that of their families or friends. Knowledge develops gradually, building piece by piece as the student progresses and is exposed to more depth and detail.

The content of this course can be made overwhelming and with little value, if the teacher becomes content-oriented. It is not necessary to know the names of all the bones or muscles. Some examples are necessary to demonstrate how muscles are attached and how they work and move the bone, but names for the sake of names or to record on a test are of little value to the average student. The teacher must be constantly selective to make the course relevant to the age and to the present and future needs of the students in the class.

Topics must be carefully chosen to match students' abilities. Students of limited ability may profitably spend more time on nutrition or smoking units than on the function of the kidneys or the endocrine system. If questions and interest arise in areas that were not originally included in the course outline, digressions to satisfy the student's curiosity should be followed. In mathematics and other science courses, a step-like progression may be necessary to prepare the groundwork for the next topic. There is much more freedom and flexibility possible in human biology.

A few generalized content suggestions are worth noting.

APPLICATION. The students need to understand that the concepts that are taught are not abstract conjectures, but are applicable to their own bodies and are applicable in wider terms to friends and family and to future children. The students need to understand that the concepts are related to society and the community in which they live, in such areas as health sanitation, water supply, and services.

BIOLOGICAL LITERACY. The students must recognize that events in the living world around them are not isolated and that they are not immune from their effects. Biological events occur: water pollution kills fish; radioactive "accidents" release gasses into their air; pesticides are present in or on foods, etc. These events affect them as individuals because they are living organisms in a biological environment.

SOCIAL IMPACT. The student must be encouraged to develop a social conscience to make sound, rational judgments in local and national policies that may affect them and all mankind.

Content cannot be divorced from skills or attitudes. All are integral parts of one scheme. Topic choices, however, are the main vehicle through which attitudes and skills are developed.

ESTHETIC SENSE. It is important not to lose sight of the beauty that is evident in the human body, and to wonder at both the complexity and the simplicity of its design and working, as well as to help students recognize what is true beauty. This can be integrated with art and fitness, giving students pride in their own bodies and the capability of their minds.

EDUCATIONAL OBJECTIVES FOR A COURSE IN HUMAN BIOLOGY

1. To provide students with a basic knowledge and understanding of the working of their own bodies.
2. To help students build positive attitudes about themselves, to be sensitive to the needs and differences in others, and to develop concerns about science in a social context.
3. To encourage students to be curious and open-minded, receptive to new ideas, and aware of the on-going progress of science.
4. To provide students with the opportunity to investigate ideas and concepts, to research information for themselves, and to place their results in some objective perspective.
5. To provide students with opportunities to build skills and engage in the processes of science: observing, forming hypotheses, identifying problems, and predicting and organizing data.

Specific objectives are listed in this manual for each chapter of the text. Objectives are also given for each activity before the preparation tips for each experiment in this manual.

STUDENT NOTEBOOKS

There are two primary types of recording that students should be required to maintain.

1. A CLASS NOTEBOOK to record the information covered in classroom teaching and discussions. It should include homework assignments and any diagrams or worksheets that are distributed by the teacher. These notes should be kept in precise order and be complete in content. The teacher should make a clear statement of what he or she expects of the student in terms of the detail and manner in which the notebooks are kept.

The class notebook serves the following purposes:

- a) it provides a record of the content covered.
- b) it forms a readily available reference of the work covered.
- c) it offers a concise set of notes for review for tests or examinations.
- d) it provides practice in extracting key ideas and important material from a mass of explanatory detail.
- e) it provides practice in drawing and making charts and graphs.

2. ACTIVITY NOTEBOOKS (preferably spiral bound) in which observations, data, comments, and conclusions about the experiments performed are recorded. The teacher should provide a specific pattern for the student, to illustrate how he or she wishes these notes to be kept.

A suggested pattern is given below. Each activity record should clearly show the following:

- a) The PURPOSE of the activity.
- b) A brief outline of the METHOD or a reference to where the method can be found in the text.
- c) The general OBSERVATIONS made during the activity. These may be references to changes that take place in colour or state, or observations of possible experimental error. It may also include ideas or questions that occur to the student during the performance of the activity.
- d) The recording of specific DATA. The production of suitable tables, charts, or graphs. Sketches or detailed drawings of cells observed under the microscope, etc.
- e) DISCUSSION or COMMENTS. The development of reasoned ideas, statements about new knowledge gained by the activity. Notes on observations made by other students during class discussion. Comparisons with the results of other students.
- f) A final SUMMARY statement or statements that reflect the original purpose of the activity.
- g) ANSWERS to questions given at the end of the activity or provided by the teacher.

If notebooks are to be conscientiously kept by the students, some evaluation by the teacher is required. How frequently the notebooks are checked may depend upon the seniority of the students, the level of students in the course, the workload of the teacher, or other factors. However, some evaluation should be made on a regular basis. A clear statement of what is required should be given at the commencement of the year, and a consistent effort should be made to maintain student standards throughout the course.

ACTIVITIES

Activities must be given high priority in a human biology course. They provide powerful motivation and interest for the student, help the student to understand his or her own body, and provide a basis for recognizing each individual's unique identity. Such awareness can be a very positive force in improving a student's self-image. Activities can also be used to reinforce information that students have read or learned in class, or to introduce new material.

Personal-involvement activities are especially useful in breaking up long periods, as they allow students to learn something specific about themselves.

Many teachers will be surprised by the number of students with valid driving licences who cannot read an eye chart at the required regulation distance. Students who smoke are often shocked to discover that even minimal smoking habits produce detectable physiological changes in their bodies that place them at a disadvantage to their non-smoking companions. Heart rate changes on a pulse-monitor, which fluctuates rapidly with some slight emotional stimulus, will often delight a class. Such experiments bring vitality to the subject matter and are often highlights in the learning program.

Activities in human biology are not a casual adjunct to the course content, but must be a prominent and integral part of the program; their value cannot be too highly stressed.

Students learn best through "doing", by involvement in processes of learning in which all the senses are involved, not just the ears or eyes. Teachers must use this opportunity to full advantage.

Activities in human biology do not, in most cases, require expensive equipment, or apparatus that is difficult to prepare. The few pieces that do involve cost (a skeleton or spirometer, for example) can often be purchased in partnership with the Physical Education department. Equipment such as this may already be in the school for use in senior biology classes.

Teachers who make activities a prominent part of their course will be richly rewarded by the enthusiasm and satisfaction expressed by their students and by the delight they show at discovering a course that has meaning and relevance to their daily lives.

Unit 1

**What Are We
Made Of?**

Chapter 1

Knowledge of the Human Body

Chapter Focus

The body is essentially chemical in nature. If it is to grow and develop in a healthy way, certain elements and compounds must be provided.

This chapter provides some background for studying the chemical composition of the body and the many chemical reactions that will be introduced later.

The *cell* is the basic unit that makes up all tissues and organs within the body. The concept of the cell is therefore developed in some detail, and leads into a discussion of the differentiation of cells and tissues. Each tissue has its own design, which fits it for the special function it is to perform.

Human cells cannot function in isolation. There must be a constant supply of nutrients and oxygen and regular discharge of wastes. The movement of molecules in and out of the cell is important in establishing the cell as a living, working unit.

Objectives

After studying this chapter, the student should be able to

- list the major elements found in the human body
- list the substances found in food
- list the major functions of water
- state the importance of the cell in the study of human biology
- list the cellular organelles, describe their structures, and state their functions
- define diffusion and osmosis and explain these processes
- give examples of osmosis and diffusion in the human body
- distinguish between active and passive transport
- differentiate between pinocytosis and phagocytosis
- state, in a series of simple steps, the process of cellular respiration
- describe the stages and end results of mitosis

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Chemical Composition of the Body	*	
What Is Food Made Of?	*	
Water	*	
The Cell and its Parts	*	
The Cell Membrane	*	
The Organelles	*	
Cell Processes	*	
Diffusion	*	
Osmosis	*	
Dialysis		*
Active Transport	*	
Pinocytosis		*
Phagocytosis		*
Cell Respiration	*	
Enzymes	*	
Cell Division	*	
Mitosis	*	
Meiosis		*

Teaching Suggestions

Many students have difficulty understanding the three-dimensional quality of cells when they view them through a microscope. This is also the case when cell drawings and projectors are used, since these representations are usually flat. Models of the cell are useful, but as these may be expensive, the best idea might be to have students construct their own models, using styrofoam materials. These models are inexpensive and easy to build.

Electron micrographs, which show the fine structures of cells, are most useful for understanding cell organelles and their density (numbers). These may be purchased in the form of 35 mm slides or photographs.

For demonstrating *osmosis*, pieces of potato can be cut into rectangular strips and the lengths measured. These strips are then immersed in a concentrated solution of salt and tap water. After 30 min, the size and turgidity of the strips are measured and noted.

Blood cells burst when added to a drop of hypotonic solution (less than 0.9%); when cells are added to a drop of a hypertonic solution (greater than 0.9%) of solute or salt, they will shrink or crenate. These changes in the condition of blood cells can be observed under high power.

For the study of mitosis, whitefish prepared slides and/or 35 mm slides should be used.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 36)

- | | |
|--------------------------|------------------|
| 1. vacuoles | 6. cell membrane |
| 2. pinocyte | 7. chromosomes |
| 3. mitochondrion | 8. cytoplasm |
| 4. Golgi bodies | 9. microvilli |
| 5. endoplasmic reticulum | 10. centrioles |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 36)

1. Student self-test (see text, page 17).
2. Student self-test (see text, pages 19-21).
3. The unit membrane must keep important molecules inside the cell and allow wastes to diffuse out. It must also allow important metabolites to enter. The nuclear membrane must control the passage of substances in and out of the nucleus. Membranes separate and organize special substances, such as enzymes, within the cell. The membranes around such organelles as the mitochondria and Golgi bodies enable specialized reactions to take place in isolation from the rest of the cytoplasm.
4. Cells vary in size and shape according to the role they perform. For example, lining cells may be flat or columnar. Nerve cells are long because they have to carry impulses far away from the points of stimuli.
5. *The Functions of Water*
 - a) to dissolve and mix with nutrients
 - b) to combine with larger molecules in enzymatic reactions in order to form simpler substances
 - c) to bathe tissues and cells, which prevents drying out, and, for more efficient transport of substances
 - d) to act as a lubricant, reducing friction
 - e) to control body temperature
6.
 - a) Phagocytosis is the process by which large particles (including bacteria) are engulfed and enclosed within the cell membrane.
 - b) Pinocytosis refers to the sinking or extruding of the cell membrane and the formation of a small sac, which encloses small particles and fluids. This facilitates their movement across the membrane.
 - c) Osmosis refers to the movement of water molecules from a region of high water concentration (or low solute) to a region of low water concentration (or high solute) across a semipermeable membrane.
7. Interphase: DNA duplicates. Cell is active.
Prophase: Chromatids appear, nuclear membrane disappears, centrioles divide and move to each pole. Spindle fibres appear. Double chromatids scatter in the nuclear region.

Metaphase: Double chromatids migrate to the equator of the cell. Spindle fibres attach at centromere.

Anaphase: Two chromatids split at the centromere and are pulled by spindle fibres to each pole.

Telophase: Chromosomes reach polar regions. Nuclear membrane reappears. Cytoplasm divides.

8. Mitosis takes place in the cells of all tissues except the muscles and nerves. A high rate of cell division (mitosis) occurs in the bone marrow, under the epidermis of the skin, and in the hair root.
9. Cells must metabolize; that is, they must carry out such cellular reactions as respiration and digestion. In the process they break down sugars, proteins, and fats, producing energy and metabolic wastes. Cells also build up complex proteins, fats, and glycogen.
10. Temperature, size of the molecules, and the concentration gradient are factors that affect the rate of diffusion. The solubility of the substance in the fluid and the molecular weight are additional factors.

Text Activities

ACTIVITY 1: INVESTIGATING THE STRUCTURE AND FUNCTION OF CELLS (TEXT, PAGE 37)

MATERIALS

live amoeba (*Amoeba proteus* or chaos), live *Tetrahymenae pyriformis* (or a similar small protozoan for food), slides, coverslips, eye droppers, compound microscope

ACTIVITY OBJECTIVES

1. to observe a living cell
2. to observe phagocytes
3. to improve microscopic skills and drawing

PREPARATION TIPS

A boiled yeast suspension may be used as food for the amoeba. Add Congo red powder to the yeast suspension to make the food easier to see after ingestion. Students may not see the actual formation of the food vacuoles, but they should see the red dye, or any small organisms used for food, in the vacuoles. The red dye changes to a darker colour as the digestion progresses.

Paramecia may be substituted for amoeba as they are single-celled organisms. The nature of the two portions of the cytoplasm may be considered: the plasmasol, which is more fluid, and the plasmagel, which is less fluid. Many human cells, including cartilage cells, show remarkable cytoplasmic streaming, and this process may be seen in many single-celled protozoans. The engulfing of food particles by an amoeba is similar to the action of a

white blood cell in destroying bacteria.

ANSWERS TO QUESTIONS

1. Phagocytes are cells that are capable of surrounding and totally engulfing bacteria, food, or small particles.
2. Students should observe the following: cell membrane, nucleus, nucleolus, granules, and cytoplasm.

ACTIVITY 2: OBSERVING HUMAN CHEEK CELLS (TEXT, PAGE 38)

MATERIALS

toothpicks, glass slides, coverslips, 1% methylene blue, iodine solution, compound microscope

ACTIVITY OBJECTIVES

1. to improve microscopic skills
2. to make observations and practise drawing
3. to observe examples of squamous epithelial cells

PREPARATION TIPS

If ready-made stock solutions of methylene blue are not available, they should be prepared as follows: Add 1.5 g of methylene blue to 100 mL 95% ethyl alcohol. This is the stock solution. For use, add 10 mL of the stock solution to 90 mL distilled water. *To prepare the iodine solution*, add 3 g of potassium iodide crystals to 25 mL water. Stir in 0.6 g of iodine crystals. Add distilled water to make a volume of 200 mL. Store in a dark bottle.

Students should be able to distinguish granules in the cytoplasm of their cheek cells. They represent a variety of cell organelles. The nucleus, when stained, should reveal chromatin material and nucleoli.

ANSWERS TO QUESTIONS

1. Epithelial cells line the surface of tubes (ducts), vessels, and skin. They may be flat, cuboidal, or columnar.
2. Cell shapes vary. Some may show folded edges. Generally, the nuclei are oval to round in shape, with a large amount of cytoplasm. These squamous epithelial cells may show four and five sides with rounded corners.
3. Most cells will be worn and damaged; these are dead cells. Most cells will show similar shapes and nuclei. Surface cells differ from deeper cells (younger cells) in the amount of cytoplasm present, and may vary slightly in shape.
4. Folded cells indicate the thin, flat nature of these cells.

Additional Activities

ACTIVITY 1.A: DIFFUSION

Before starting these experiments, make sure that you understand the following terms: diffusion, osmosis, solute, solvent.

MATERIALS

Petri dish, potassium permanganate crystals, graph paper, carmine dye, milk, glass slides, and coverslips

METHOD

1. Fill the Petri dish with cold water and carefully dry the bottom of the dish with a paper towel. Record the temperature of the water. Place the dish over a piece of graph paper and wait until the water is quite still. It is important that you do not jog the bench and disturb the water during the experiment.

2. Draw a chart in your notebook as follows:

Cold water

Number of squares solute disperses.	Time in 30-s intervals.
--	----------------------------

3. Gently drop a small crystal of potassium permanganate into the water, trying to centre it over one of the major crossed lines on the graph paper below the dish.
4. Start timing as soon as the crystal hits the water. After 30 s, count the number of squares on the graph paper that the dye now covers. Halve this number, or measure from the centre to the outside of the dye stain and record the result in the chart.
5. Every 30 s note the number of squares the dye covers and record this data in the chart. Continue this sequence for at least 5 min. Make a new chart and head it "Hot water". Throw away the contents of the dish and refill it with hot water. Take the temperature of the water and record it in your notebook. Repeat the experiment using the hot water. Graph the data you have obtained showing both lines on the same graph axis. Use a different colour for each of the two lines.

QUESTIONS

1. What differences do the graphs show between the rates of diffusion? Explain why these differences occur.

continued . . .

2. Are the lines of the graphs straight or do they curve up or down? Explain what these changes represent and why they are occurring.
3. Your teacher will place a small amount of carmine dye in a drop or two of milk on a glass slide under a demonstration microscope. After observing this slide, describe what you see and try to explain why the tiny particles are moving in this peculiar manner.

ACTIVITY OBJECTIVES

1. to practise recording data in tables and graphs
2. to note the change in the dye from high to low concentration
3. to observe the constant diffusion of the dye in all directions
4. to observe that the dye moves more rapidly in warm water
5. to observe that substances move in random molecular motion from high to low concentration

PREPARATION TIPS

Methylene blue crystals may be used instead of potassium permanganate crystals. You may also use iodine crystals with alcohol and water and compare the rates of diffusion in the two solvents and the length of time it takes the crystals to dissolve. Some teachers may wish to place crystals of varying molecular weights in separate beakers to show variations in their rates of diffusion. As it takes several hours to recognize the different rates of diffusion, the examples should be left undisturbed while the class proceeds with other work. The examples should be away from heat that may cause convection currents.

ANSWERS TO QUESTIONS

1. A higher temperature will increase the kinetic energy of water molecules and allow for the faster rates of diffusion.
2. As the concentration decreases, the rate of movement will also decrease. The diffusion gradient falls and the graph will curve downward to the right.
3. This demonstrates Brownian movement. The zig-zag movement is caused by carmine particles being struck by water molecules in constant random molecular motion.

ACTIVITY 1.B: OSMOSIS AND DIFFUSION

Osmosis refers to the passage of water molecules across a semipermeable membrane from an area of high concentration to an area of low concentration. Review the discussion of osmosis in the text and explain why molecules cross the membrane.

MATERIALS

large beaker (1000 mL), dialysis tubing, string, iodine solution, 5% starch solution

METHOD

1. Take a 15-cm piece of dialysis tubing, moisten it in water, and tie off the last 1.5 cm with string. Be sure that it is tightly sealed. Twisting the end of the tube before tying will help to make a good seal.
2. Fill the membrane tube with a solution of starch and then tie off the other end. Rinse the tube under the tap to remove any spilled starch solution.
3. Immerse the soft cylinder that you have made in a beaker of water containing about 10 drops of iodine solution. Wait for at least 10 min before making your observations.
4. Put a small amount of the starch solution in a small test tube and add a drop or two of iodine. Record what you observe.
5. When the time is up examine the tube in the beaker and describe any changes that have taken place. Leave the tube another 10 min before writing up your final observations.

QUESTIONS

1. What colour changes have taken place? Where exactly do the colour changes occur?
2. What explanation can you give for the changes that take place in the firmness of the sac?
3. Explain why molecules of the solution in the beaker appeared to be able to pass inside the tube, but molecules inside were unable to pass out through the membrane.
4. What is the meaning of each of the following terms: semipermeable, osmosis, diffusion?

ACTIVITY OBJECTIVES

1. to illustrate the process of osmosis
2. to demonstrate the semipermeability of membranes
3. to show that molecular size and membrane pore size determine which substances cross the membrane
4. to show the increase in pressure produced by osmosis

PREPARATION TIPS

Water and iodine solution will diffuse into the sac, as they are composed of small molecules. In the starch solution, the larger molecules will be unable to pass through the pores in the membrane. Students should note the size and firmness of the sac *before* and *after* the experiment.

ANSWERS TO QUESTIONS

1. The iodine will turn the starch blue or black in the sac. Iodine molecules will diffuse through the pores of the artificial permeable membrane into the sac.
2. Students should feel that the sac is firmer (turgid). This change has occurred because water molecules have entered into the sac. Some water molecules would leave the sac, but the net flow of water is into the sac, which has a higher solute concentration.
3. Consider the pore size of the membrane. Starch molecules are too large to pass out of the sac, but iodine and water move freely through the pores.
4. Semipermeable describes a membrane that allows some substances to pass through but prevents others from entering or leaving.

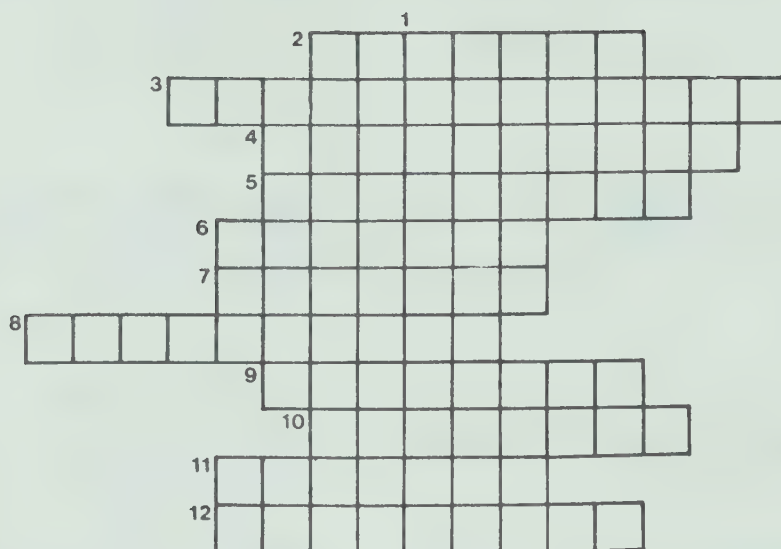
Osmosis is a special kind of diffusion in which only water molecules move back and forth from cell to cell. There is no net movement if the concentration of water is the same in adjacent cells.

Diffusion is the mixing of solutes and solvents such as oxygen and water, or glucose and water. Passive diffusion involves movement from a high to a low concentration. Facilitated diffusion, or active transport, requires energy or carrier molecules and involves diffusion from a low concentration to a high concentration.

Self-test: Select the best answer.

1. Which one of the following elements is most common in the human body?
 - a) oxygen
 - b) carbon
 - c) hydrogen
 - d) nitrogen
2. Which of the following food substances does not provide energy?
 - a) fats
 - b) proteins
 - c) minerals
 - d) carbohydrates
3. Which of the following is not a function of water in the body?
 - a) acts as a solvent
 - b) helps control body temperature
 - c) forms a major part of the body lubricants
 - d) increases the density of the body
4. Which of the following is not a true statement?
 - a) Active transport involves the movement of molecules from a lower concentration to a higher concentration.
 - b) Active transport requires a supply of energy.
 - c) Active transport may require the use of ferry molecules.
 - d) Active transport results from the random molecular motion of molecules.
5. The unit membrane is composed of
 - a) lipids
 - b) proteins
 - c) proteins and lipids
 - d) neither proteins nor lipids
6. The organelle responsible for making energy available to cells is the
 - a) mitochondrion
 - b) Golgi apparatus
 - c) ER
 - d) vacuole
7. The organelle that produces or accepts enzymes for packaging and redistribution is the
 - a) mitochondrion
 - b) ER
 - c) centriole
 - d) Golgi apparatus
8. Osmosis refers to
 - a) the diffusion of molecules from a high concentration to a low concentration
 - b) movement of molecules from a low to a high concentration
 - c) movement of water molecules from a high to a low concentration
 - d) movement of solutes from a low to a high concentration
9. If red blood cells are placed in water, the cells will
 - a) burst
 - b) shrink
 - c) stay the same
 - d) change colour
10. Which of the following is not a true statement?
 - a) Mitosis involves the production of two identical daughter cells.
 - b) Mitosis takes place in all cells.
 - c) Mitosis involves the doubling or replication of the chromosomes.
 - d) Mitosis implies the movement of water across a semipermeable membrane.

Crossword



ACROSS

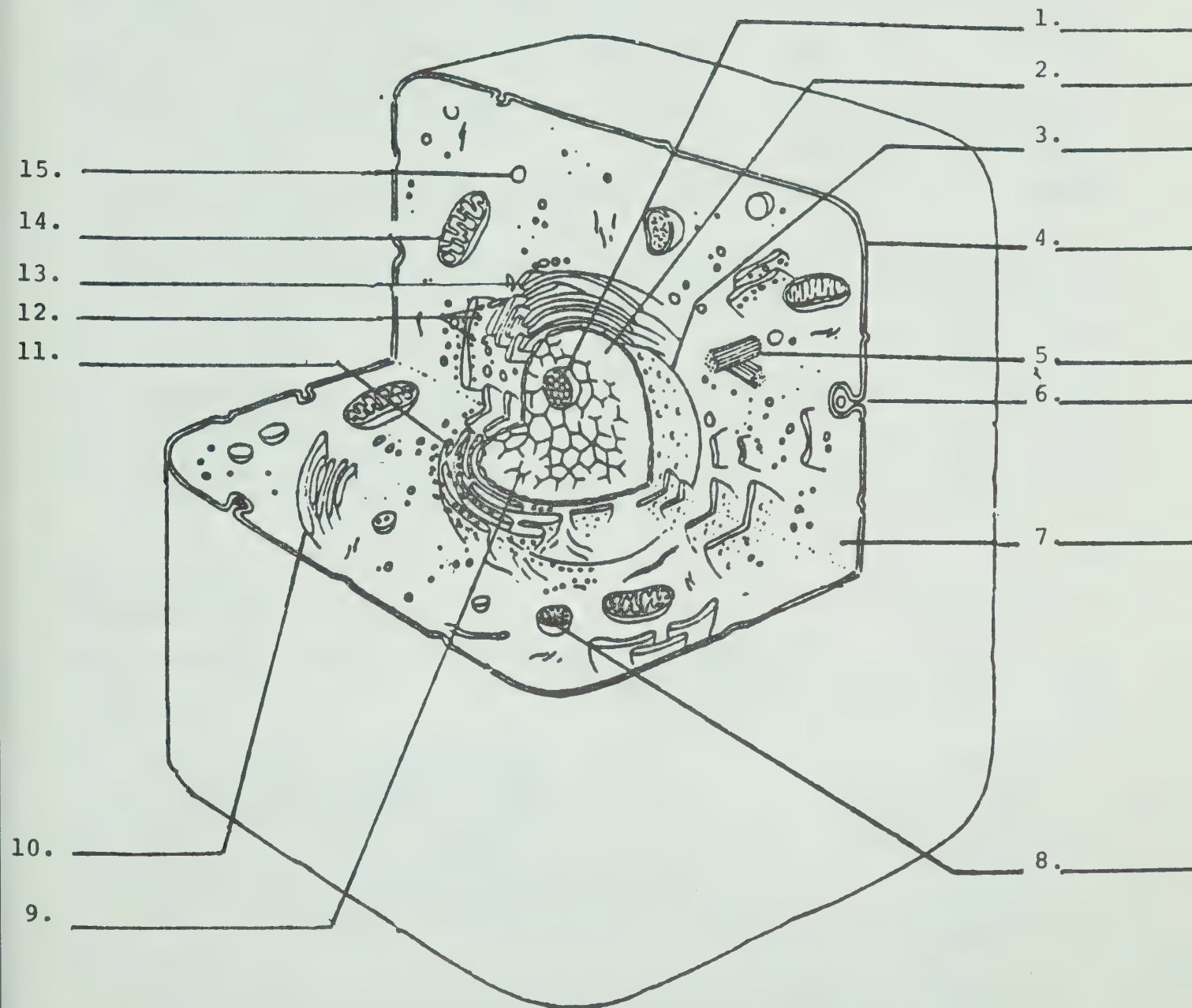
2. control centre of the cell
3. "power house" of the cell
4. small finger-like extensions on the cell membrane
5. cell contents, except the nucleus
6. found in the lysosomes
7. membrane-covered "bubble", often filled with water
8. basic living substance of which all living things are composed
9. small "bulge" in the cell membrane
10. outer "skin" of the cell
11. a major part of the cell membrane is composed of this
12. small sacs containing enzymes

DOWN

1. What mystery word is formed here?

A Typical Cell

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. a) | 6. a) |
| 2. c) | 7. d) |
| 3. d) | 8. c) |
| 4. d) | 9. a) |
| 5. c) | 10. d) |

ANSWERS TO CROSSWORD

ACROSS

2. nucleus
3. mitochondrion
4. microvilli
5. cytoplasm
6. enzymes
7. vacuole
8. protoplasm
9. pinocyte
10. membrane
11. protein
12. lysosomes

DOWN

1. chromosomes

LABEL ANSWERS FOR "A TYPICAL CELL"
(Taken from Figure 1.3., text page 17)

- | | |
|---------------------|----------------------------------|
| 1. nucleolus | 9. chromatin net |
| 2. nucleus | 10. smooth endoplasmic reticulum |
| 3. nuclear membrane | 11. rough endoplasmic reticulum |
| 4. cell membrane | 12. ribosomes |
| 5. centrioles | 13. Golgi apparatus |
| 6. pinocyte | 14. mitochondria |
| 7. cytoplasm | 15. vacuoles |
| 8. lysosomes | |

Selected Readings

1. Baver, William, F. H. Crick, and James White, "Supercoiled DNA," *Scientific American* (July 1980).
2. Grobstein, Clifford, "Recombinant DNA - Debate," *Scientific American* (July 1977).

3. Hayflick, Leonard, "The Cell Biology of Human Aging," *Scientific American* (January 1980).
4. Hinkle, Peter C. and Richard McCarty, "How Cells Make ATP," *Scientific American* (March 1978).
5. Karp, G., *Cell Biology* (New York: McGraw-Hill, 1979).
6. Lazarides, Elias and Jean-Paul Revel, "Molecular Basis of Cell Movement," *Scientific American* (May 1979).
7. Lodish, Harvey F. and James E. Rothman, "The Assembly of Cell Membranes," *Scientific American* (January 1979).
8. Minicourse Development Project. B.S.C.S. Staff Publications, "Genetics" and "The Working Cell," (Philadelphia: W. B. Saunders, 1976).
9. Mirsky, Alfred E., "The Discovery of DNA," *Scientific American* (June 1968).
10. Richards, Victor, *The Wayward Cell - Cancer* (Berkeley, Calif.: University of California Press, 1972).
11. Staehelin, L.P. and B.E. Hull, "Junctions between Living Cells," *Scientific American* (May 1978).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Gene Action." 16 min col., EBE
2. "The Living Cell: DNA." 20 min col., EBE
3. "Living Cell." 20 min col., EBE
4. "Mitosis." 24 min col., EBE
5. "Meiosis: Sex Cell Formation." 10 min col., EBE
6. "Diffusion and Osmosis." 14 min col., EBE
7. "DNA: Molecule of Heredity." 16 min col., EBE

35 mm SLIDES

1. "Electron Micrograph." 40 slides. Carolina Biological
2. "Whitefish Mitosis." 10 slides. Carolina Biological

FILMSTRIPS

1. "Introduction to DNA." With cassette. Wards Solo Learn Program, Arbor Scientific, Ont.
2. "Osmosis and Diffusion." With cassette. Wards Solo Learn Program, Arbor Scientific, Ont.

Chapter 2

Tissues and Organs

Chapter Focus

The major concept in this chapter is that each cell has a unique structure which enables it to perform its specific role within the body.

Students do not readily perceive the relationship between cell structure and function until it is pointed out to them. Muscle cells have the unique capacity to contract, and their shape and structure are designed to support this function. Their energy requirements are high; therefore the number of mitochondria they contain is quite large. Unless this relationship is stressed, the study of tissues becomes a meaningless list of names to be memorized.

This concept of the relationship of structure and function is extended to organs, which are integrated collections of tissues. Each tissue contributes its own special adaptations to the common function of the whole organ.

Objectives

After studying this chapter, the student should be able to

- identify the four basic tissue groups in the body
- describe the various types of tissue and give examples of their location in the body
- relate structure to function in cell design
- define the terms *cell*, *tissue*, *organ*, and *system*, and explain their relationships in the body
- list the cavities in the body and be able to list the major organs they contain
- recognize the terms used to establish direction and location in the body

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Tissues of the Body	*	
Epithelial Tissue	*	
Muscle Tissue	*	
Connective Tissue	*	
Nerve Tissue	*	
Organs and Systems	*	
The Cavities of the Body		*
Directions in the Body		*

Teaching Suggestions

A good histology atlas provides many photographs and illustrations of the different tissues. Refer to the "Selected Readings" list. Two good references are Nilsson's *Behold Man - A Photographic Journey inside the Human Body* and Kardon and Kessel's *Tissues and Organs*. An excellent set of 35 mm slides that accompanies the latter text is available from Carolina Biological. However, the use of microscopic slides, suggested in Activity 1, as well as other slides of the trachea, nerve tissue, and cartilage would suffice. Students should refer to Table 2.1, which provides a good summary of tissue structure and function.

The use of worksheets that direct the student's study of microscope slides or viewer study guides (from Wards) are most useful. These exercises encourage good observational techniques, improve drawing skills, and help the student to understand the structure and function of tissues.

Sometimes it is necessary to remind students of the extremely small size of the electron micrograph details.

It is important to explain to the students the place of each tissue in the total organization of the body. The simplified diagram at the bottom of page 54 may help. Tissues do not exist in isolation. While they may be separated for study, their integrated roles in the body and the way in which many tissues combine to form complex organs must be firmly established.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 55)

- | | |
|-----------------------------------|----------------------------------|
| 1. epithelium | 6. cartilage |
| 2. skeletal muscle | 7. nerve tissue |
| 3. cardiac muscle | 8. bone |
| 4. stratified squamous epithelium | 9. smooth muscle |
| 5. adipose tissue | 10. ciliated columnar epithelium |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 55)

1. The epithelial tissue protects the body's external and internal surfaces. Ciliated epithelial cells, which line the trachea, rid the trachea of debris that could be trapped in the respiratory system. Goblet cells, which line the trachea and intestines, secrete mucus to keep surfaces moist. The outer layer of skin cells are dead and help to protect underlying new cells. They are toughened and waterproofed with special secretions.
2. Voluntary muscles, attached to the skeleton, function by conscious control. Involuntary muscles are controlled by the autonomic nervous system and cannot be controlled by the will of the individual. Involuntary muscles or smooth muscles line tubes and ducts such as the blood vessels, ureter, and digestive tract.

3.
 - a) columnar epithelium - Tissue
 - b) neuron - Cell
 - c) cardiac muscle - Tissue
 - d) fat - Tissue
 - e) liver - Organ
 - f) circulation - System
 - g) oxygen - Element
 - h) digestion - System
 - i) protein - Compound

4.

Cell: the fundamental unit, of which all organisms are composed, consisting of cytoplasm and a nucleus or nuclear material.

Tissue: an aggregation of cells of more or less similar structure and function.

Organ: a part of an organism that has a definite form and structure and that performs one or more specific functions. It is composed of several tissues.

System: an organized group of related organs that work together to provide a special function.

Organism: a living entity that can metabolize and reproduce.

5.

The pancreas is used as an example.

Function of pancreas: to produce digestive enzymes (amylase, lipase, trypsin, etc.) which pass into the small intestine to digest starch, fats, and proteins. Two important hormones, insulin and glucagon, are involved in glycogen-sugar metabolism. The enzymes are produced in pancreatic cells. The islets of Langerhans produce the hormones.

6.

The endocrine system is used as an example.

The endocrine system is composed of the pituitary, thyroid, parathyroid, and adrenal glands and the pancreas, testes, and ovaries. Each gland produces a specific hormone or hormones which are secreted into the blood stream and carried to another part of the body to produce a specific effect, stimulating or inhibiting (regulating) that part of the body.

7.
 - a) pancreas - abdominal cavity
 - b) lungs - thoracic cavity
 - c) stomach - abdominal cavity
 - d) liver - abdominal cavity
 - e) heart - thoracic cavity
 - f) brain - cranial cavity
 - g) ovaries - abdominal cavity
 - h) intestines - abdominal cavity

8. Refer to Figure 2.15, text, page 54.

9. Sinuses are channels or spaces in the bones of the skull. The nasal cavities are located above the hard palate between the external and internal nostrils.

10.

Lateral: a position away from the midline. For example, the ear is on the lateral part of the cranium.

Medial: a position close to the midline. For example, the nose is medial

to the eyes.

Distal: a position further from the point of attachment or midline. For example, the fingers are distal to the wrist.

Anterior: refers to the front or belly side of the body. For example, the jaw is on the anterior part of the head.

Text Activities

ACTIVITY 1: EXAMINATION OF PREPARED SLIDES OF BODY TISSUES (TEXT, PAGE 56)

MATERIALS

prepared slides of blood smear, epithelial tissues (skin, small intestine, trachea), three kinds of muscle, bone sections, adipose tissue, pancreas, nerve tissue

ACTIVITY OBJECTIVES

1. to improve drawing and microscopic skills
2. to demonstrate the variety of cells present in the body
3. to compare the structures of cells and relate structure to function
4. to identify the major types of tissue

PREPARATION TIPS

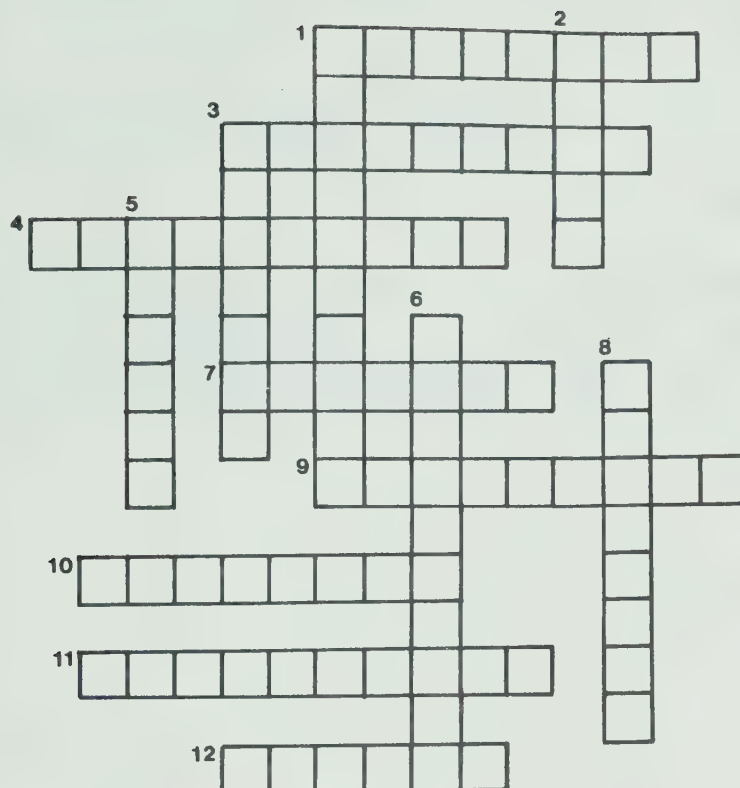
Students should be less concerned about the fine details of cell structure and concentrate on the function, arrangement, and organization of the kinds of cells and tissues. For example, the cuboidal cells of the pancreas are secretory in nature whereas the flat epithelial cells are protective. Tissues of any gland, which show cuboidal cells, could be used.

Some students may wish to prepare fresh tissue mounts. Chicken legs provide a useful supply. Thin pieces of tendons from muscles may be used after they are soaked in saline solution and stained with iodine or carmine solution. Cartilage and bone cells can be scraped off from tissues and stained with iodine for observation. Other fresh tissues may be prepared in a similar manner if prepared slides are unavailable.

Self-test: Select the best answer

1. Smooth muscle is found in the
 - a) muscles of the arm
 - b) muscles of the heart
 - c) muscles of the intestine
 - d) muscles of the tongue
2. Fat storage takes place in
 - a) the spaces between the cells
 - b) adipose tissue
 - c) the epidermis
 - d) none of these
3. Cells that line the surface of the body or of an organ are called
 - a) epithelial
 - b) connective
 - c) adipose
 - d) endothelial
4. Which of the following is not a tissue?
 - a) epithelium
 - b) heart
 - c) muscle
 - d) nerve
5. When several tissues combine to perform some common function they form
 - a) cells
 - b) tissues
 - c) organs
 - d) systems
6. Which of the following organs does not belong to the digestive system?
 - a) pancreas
 - b) liver
 - c) intestines
 - d) bladder
7. Which of the following organs is not found in the abdominal cavity?
 - a) ovaries
 - b) kidneys
 - c) heart
 - d) pancreas
8. In which cavity of the body is the heart found?
 - a) thoracic
 - b) abdominal
 - c) pelvic
 - d) cranial
9. Which of the following terms is used to describe the position of an organ located in front of another?
 - a) posterior
 - b) anterior
 - c) medial
 - d) lateral
10. Which of the following terms is used to describe a position close to the centre line of the body?
 - a) lateral
 - b) proximal
 - c) medial
 - d) ventral

Crossword



DOWN

1. layers of squamous cells in the skin
2. several types of tissues combining to provide a common function
3. heart muscle
5. type of muscle found along the digestive tract
6. bone and cartilage belong to this group of tissues
8. in front

ACROSS

1. thin, flexible epithelial cells
3. flexible support tissue
4. microvilli facilitate this process
7. fat tissue
9. the receiving end of a neuron
10. chest cavity
11. surface lining tissue cells
12. several organs combining to provide a common function

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. c) | 6. d) |
| 2. b) | 7. c) |
| 3. a) | 8. a) |
| 4. b) | 9. b) |
| 5. c) | 10. c) |

ANSWERS TO CROSSWORD

DOWN

1. stratified
2. organ
3. cardiac
5. smooth
6. connective
8. anterior

ACROSS

1. squamous
3. cartilage
4. absorption
7. adipose
9. dendrites
10. thoracic
11. epithelium
12. system

Selected Readings

1. Bloom, William and F. Bloom, *A Textbook of Histology* 10th Ed. (Philadelphia: W.B. Saunders Co., 1975).
2. Gordon, Richard and Antone G. Jacobson, "The Shaping of Tissues in Embryos," *Scientific American* (June 1978).
3. Grollman, Sigmund, *The Human Body* 3rd Ed. (New York: Macmillan Co., 1974).
4. Kessel, R. and R. Kardon, *Tissues and Organs: A Text-Atlas of Scanning Electron Microscopy* (San Francisco: Freeman and Co., 1979).
5. McClintic, Robert J., *Basic Anatomy and Physiology of the Human Body* 2nd Ed. (New York: John Wiley & Sons, 1980).
6. Nilsson, Lennart, *Behold Man - A Photographic Journey inside the Human Body* (Boston: Little, Brown and Co., 1973).
7. Vander, Sherman, *Human Physiology* 2nd Ed. (New York: McGraw-Hill, 1975).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Man: The Incredible Machine." 28 min col., National Geographic, Box 2895, Washington, D.C. 20013, U.S.A.

35 mm SLIDES

1. Tissues and Organs Slide Set from *A Text-Atlas of Tissues and Organs*. Carolina Biological Supply Co.
2. Human Functional Anatomy Slide Set from *The Johns Hopkins Atlas of Human Functional Anatomy*. Carolina Biological Supply Co.

Unit II

Our Outer Protective Covering

Chapter 3

The Skin

Chapter Focus

The skin is the body's largest organ. It is important because it provides the interface between the external and internal environments of the body.

The experiments in this chapter provide the first opportunity for many students to see themselves as unique: they are similar to, yet different from, others around them. We do not all have the same sensitivity to heat, cold, touch, or pain. We have different skin patterns and hair characteristics. Unlike many science experiments in which students are expected to obtain results that are very similar to those of other members of the class, observations here will differ greatly from one student to another.

The excitement and interest generated by the binocular microscopic examination of the student's own skin is as valuable as the knowledge gained. Capitalize on this interest and it will pay dividends in other parts of the course.

For teenagers, the skin and its attendant problems are very important. Skin care and related questions should be actively encouraged.

Objectives

After studying this chapter, the student should be able to

- list the major functions of the skin
- label a diagram of the skin showing the various structures
- describe the structures of the skin and state their functions
- describe the structures and functions of the appendages of the skin: hair, nails, and glands
- list the sensory receptors in the skin
- explain how the skin aids in the regulation of body temperature
- describe the basic action the body takes when it has been exposed to severe cold
- know common skin problems and treatments

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Characteristics and Functions of Skin	*	
The Structure of the Skin	*	
The Epidermis	*	
The Dermis	*	
Appendages of the Skin		*
Sense Receptors in the Skin	*	
Regulation of Body Temperature	*	
How to Conserve Body Heat in an Emergency	*	
Some Common Skin Features		*
Some Skin Problems		*
Care of the Skin		*

Teaching Suggestions

One of the reasons for placing the study of skin early in the text is that the topic offers opportunities for simple, straightforward activities that capture the student's interest. Some parts of the chapter may be developed into open-ended projects to be completed by the class or by individual students. For example, a police officer would be willing to visit your class to explain the method used to identify fingerprints and palm prints. Another idea is to devise an experiment to test the pH and protein levels of shampoos (some misleading advertising occurs in this area). This is also an excellent opportunity to invite to the classroom an outside speaker on cosmetics or dermatology. Students do need guidance on skin care and would appreciate advice on skin problems.

Two excellent films are available concerning temperature regulation and hypothermia (see "Visual Aids"). The film called "Regulation of Body Temperature" shows the operation of the hypothalamus and other ways in which body temperature is kept constant. The University of Victoria in British Columbia publishes a pamphlet entitled "Cold Water Safety". They have also produced a 30 min film, "Man in Cold Water", which may be rented or purchased.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 74)

- | | |
|--------------------|-------------------------|
| 1. dermis | 5. stratum germinativum |
| 2. melanin | 6. keratin |
| 3. stratum corneum | 7. epidermis |
| 4. sebaceous gland | 8. sebaceous gland |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 74)

1. See Table 3.1, text, page 59.
2. As old cells are sloughed off from the epidermis due to wear and tear, new cells are constantly produced in the region between the dermis and epidermis. This is the germinal layer or the stratum germinativum. This layer is responsible for the production of the epidermal cells.
3. It is unique in the degree of pigmentation, special marks or lines (finger prints), distribution of sweat glands and sebaceous glands, and hair density or distribution.
4. Sweat contains organic wastes, substances such as urea and ammonia. Sebaceous glands secrete a product rich in organic compounds. These products are odoriferous. These compounds may be attacked also by bacteria in the skin and produce additional substances that contribute to body odour.

5.

RECEPTOR	SENSATION
Meissner's corpuscle	Touch
Pacinian corpuscle	Pressure
Sensory end bulbs	Heat esp. between 35-40°C
Sensory end bulbs	Cold esp. between 15-20°C
Naked nerve endings	Pain

6.
 - a) Sympathetic impulses increase the metabolic rate, skin vessels constrict, sweating is inhibited, and shivering is promoted.
 - b) Blood vessels dilate, producing more sweat.
 - c) Skin vessels constrict. Contraction of arrector muscles causes the skin to raise into tiny bumps called "goose flesh".
 - d) Sweat glands are activated. Chemical reactions take place converting fatty substances into vitamin D. Radiation from the sun causes increased production of melanin, a process called tanning. Excessive sunlight causes the skin to dehydrate and makes it more "leathery".
7. Special areas, such as lips, have many nerve endings but completely lack sweat glands. Exposed surface areas such as the forehead and the palm of the hand possess a large number of sweat glands. The palms are often required to grip objects firmly; no sensory hairs are present.
8. The continuous exposure of the hands to heat and cold, and the thicker epithelial layer produced by manual work would make the hands more insensitive than the elbow. Greater distribution of heat and cold receptors are present on the elbow.

9. Student answers will vary.
- Stratum germinativum: columnar epithelial cells which possess large stained nuclei which are active in cell division.
 - Follicle: a small hollow structure around the hair root. These cells form the growing hair. The cells keratinize to produce the hard cuticle which makes the hair shaft rigid.
 - Sebaceous glands consist of large cells with tiny or no nuclei. They allow for storage of the fatty substance sebum in the cytoplasm.
 - Chromatophore cells engulf pigments manufactured by melanin-producing cells. Chromatophores literally phagocytose pigments in the dermis.
10. Because of the large surface area (1.75 m^2) - its mass forming about 7% of the body - and its many protective functions, the skin is usually called an organ or, for that matter, a system (the intergumentary system). The skin is composed of several tissues which combine to serve one function, that of protecting the internal body.
11. Sebaceous glands secrete sebum, an oily substance, through short ducts around the follicle of the hair shaft to the skin surface. Production is slow and continuous. Sweat glands consist of secretory units in the lower dermis. Blood capillaries come close to these secretory units where sweat, a salty, watery fluid, is secreted and passed on to the excretory ducts which emerge at the skin surface.

Text Activities

ACTIVITY 1: TEMPERATURE (TEXT, PAGE 75)

MATERIALS FOR ACTIVITIES 1 - 4

straight pin, small finishing nail, 2 beakers, ice cubes, dividers, ruler, cotton thread, soap, rubber stamp (2.5 cm^2) divided into 100 squares

ACTIVITY OBJECTIVES

- to investigate skin sensations
- to recognize the numbers and variety of nerve endings in the skin
- to demonstrate the different kinds of nerve endings responsible for different stimuli

PREPARATION TIPS

The rubber stamp can be made to order quite cheaply and purchased through most office supply stores. You may also use water-soluble ink to allow students to draw a grid with 100 squares. A water bath could be used in maintaining the temperature at approximately 60°C . There are almost as many heat and cold receptors present on the inner surface of the wrist. However, "cold spots" outnumber "warm spots" throughout the body. Students may discover about 25% of these receptors in their grid areas. The elbow would possess many more

heat receptors than the surface of the hand, and an infant's bath water should be tested with the elbow. The hand also possesses more keratinized epithelial tissue and is less sensitive to heat.

ACTIVITY 2: PAIN AND PRESSURE (TEXT, PAGE 76)

ACTIVITY OBJECTIVES

1. to demonstrate that different nerve endings are responsible for pain and pressure sensations
2. to show that pain receptors vary from one part of the body to another

PREPARATION TIPS

There appears to be fewer pain receptors on the inner wrist than "cold and hot spots". Caution students not to press too strongly on the skin. A blunt end probe should be used for pressure sensations. Ward's (Arbor Scientific) transparencies on sensations are useful for these activities.

ACTIVITY 3: TACTILE DISCRIMINATION (TEXT, PAGE 77)

ACTIVITY OBJECTIVES

1. to show that the presence of hairs on the back of the hand offer sensory stimulation

PREPARATION TIPS

This activity demonstrates the high density of touch receptors on the back of the hand as compared with the palm of the hand.

ACTIVITY 4: TWO-POINT SENSIBILITY TEST (TEXT, PAGE 77)

ACTIVITY OBJECTIVES

1. to show that nerve endings vary from one part to another on the skin
2. to show that the lips and fingertips are more sensitive than other areas of the body

PREPARATION TIPS

The pair of dividers should be sterilized with alcohol before use. The distances between touch receptors vary in different parts of the body. For example, on the back of the body, the distance of two-point sensitivity may be over 6 cm. The density of receptors on the back is therefore fewer than on the fingers.

ACTIVITY 5: WHAT STIMULI ARE REQUIRED TO RECOGNIZE DIFFERENCES IN SIMILAR OBJECTS? (TEXT, PAGE 77)

ACTIVITY OBJECTIVES

1. to demonstrate the range of tactile discrimination
2. to increase the student's awareness of his or her own sensory perceptions

PREPARATION TIPS

The list of suggested items appears on page 78 of the text; you may substitute your own material, but you should use similar objects or materials that vary only slightly.

ACTIVITY 6: AN EXERCISE IN OBSERVATION (TEXT, PAGE 79)

MATERIALS

stereoscopic dissecting microscope, centimetre ruler

ACTIVITY OBJECTIVES

1. to improve observation techniques
2. to promote awareness of skin details by stereoscopic magnification
3. to demonstrate variations in the skin of the palm and back of the hand

PREPARATION TIPS

Different students possess different arrangements of ridges and furrows on their skin. Ridges appear during the third and fourth months of fetal development. Fraternal twins have different ridge appearances. Identical twins show similar ridge appearances. These patterns are determined by hereditary factors. Regions on the skin that are subjected to wear and exposure have much keratin for protection. For example, the sole of the foot possesses a thick epidermis, whereas the abdomen has a very thin epidermis. A thick epidermis usually follows a thinner dermis. "Loose skin" is due to the continuous sloughing off of the corneum layer of the epidermis as new cells push up from the lower epidermis.

ACTIVITY 7: TEMPERATURE STIMULATION (TEXT, PAGE 80)

MATERIALS

beakers, warm and cold water

ACTIVITY OBJECTIVES

1. to demonstrate relative sensations of temperature
2. to show that sensations of cold or heat are not absolute
3. to demonstrate gradual loss of sensation with increased cold

PREPARATION TIPS

Heat is lost or gained in this activity mainly by conduction. Warm receptors respond at between 37°C and 40°C , whereas cold receptors respond at about 15°C to 20°C . Students will record different experiences.

ACTIVITY 8: DISTRIBUTION OF SWEAT GLANDS ON THE SURFACE OF THE SKIN (TEXT, PAGE 80)

MATERIALS

iodine solution 0.01-0.05 mol/L, corn starch, camel hair brushes, dissecting stereoscopic microscope or hand lens

ACTIVITY OBJECTIVES

1. to demonstrate the number of sweat glands present in a specific area of the skin
2. to approximate the number of sweat pores on the skin surface

PREPARATION TIPS

Preparation of 0.01 mol/L of iodine solution: dissolve 2.54 g of iodine crystals in 25 mL of alcohol and dilute to 1000 mL with distilled water. Stock solution should be kept in a dark bottle. Blue dots should appear on the printed paper. The dots indicate sweat pores. The number of sweat glands will vary from less than $100/\text{cm}^2$ to as many as $1200/\text{cm}^2$ on the palm of the hand.

ACTIVITY 9: THE EFFECT OF EXERCISE ON BODY TEMPERATURE (TEXT, PAGE 81)

MATERIALS

thermometer, alcohol, cotton

ACTIVITY OBJECTIVES

1. to demonstrate the heat increase generated by activity
2. to illustrate the need for homeostatic control of body temperature

PREPARATION TIPS

A clinical thermometer is preferable to a standard laboratory model and should be sterilized with alcohol and rinsed with cool tap water before use. During exercise, blood is shunted from the skin, digestive system, and kidneys, and directed to the muscles which demand more oxygen. The temperature of the skin drops slightly. Students may place a thermometer under the armpit in addition to taking the oral temperature. The thermometer should not be removed from these positions while recording is carried out.

Additional Activities

ACTIVITY 3.A: TEMPERATURE VARIATIONS THAT TAKE PLACE IN THE BODY

MATERIALS

clinical thermometer, 70% alcohol, cotton pad

Most of the heat in the body comes from metabolism, primarily, the oxidation of foods. Muscles make up more than half the soft tissues of the body and supply most of the body heat. The human body must constantly work to maintain the body temperature, and this is achieved by balancing the heat loss by the amount of heat produced.

THE USE OF THE THERMOMETER

CAUTION: Use these glass instruments with care.

METHOD

1. Examine the thermometer and rotate it between your fingers until you can clearly see the line of mercury against the scale. Do a practice reading, without putting the thermometer into your mouth. Ask your partner to check your result.
2. Clean the thermometer in 70% alcohol. Shake down the mercury by holding the thermometer by the end opposite to the bulb and giving a quick downward flick of the wrist. This may need to be repeated two or three times.
3. Place the thermometer under your tongue for 4 min. Close the lips and do not try to talk while the thermometer is in your mouth.
4. Remove the thermometer and record your temperature in your notebook. Make a note of anything that might have influenced the temperature reading (just finished a physical education class, just eaten lunch, or had a hot drink, etc.). Make a table on the chalkboard and record all the class results. Calculate the class average temperature. Record this in your notebook and indicate the range of temperatures in the class. How does the class average compare with the normal accepted temperature reading?

ACTIVITY OBJECTIVES

1. to show that minor variations exist among individuals
2. to promote an awareness of temperature fluctuations
3. to show that the state of health and the metabolic activity of the individual causes temperature fluctuations

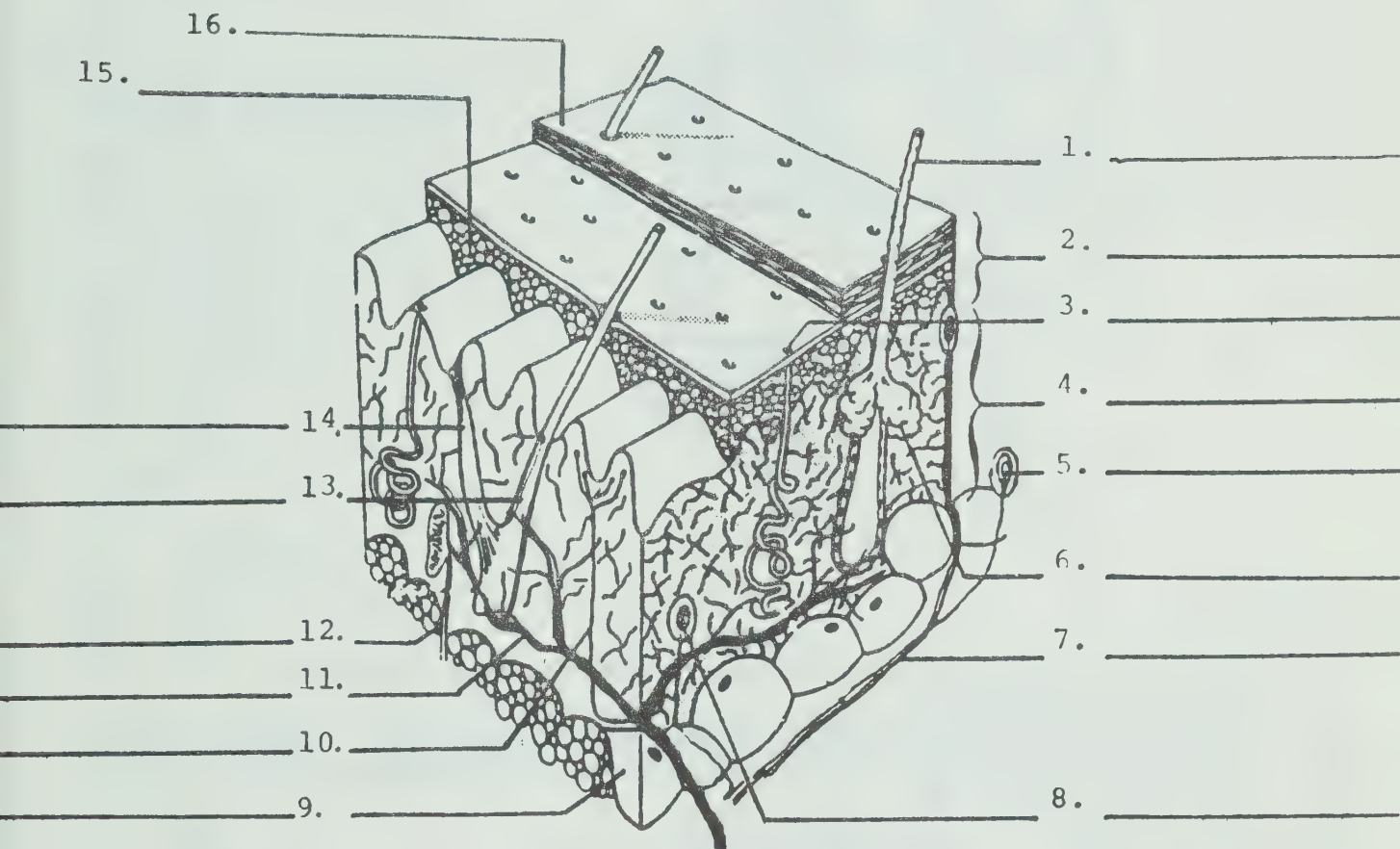
PREPARATION TIPS

A simple introduction to metabolism and metabolic rate would fit at this time. Students may wish to know how the metabolic rate is determined. Muscular activity, oxidation of foods, emotions, and other factors affect the metabolic rate. Students could be given the factors that cause heat gain and heat loss.

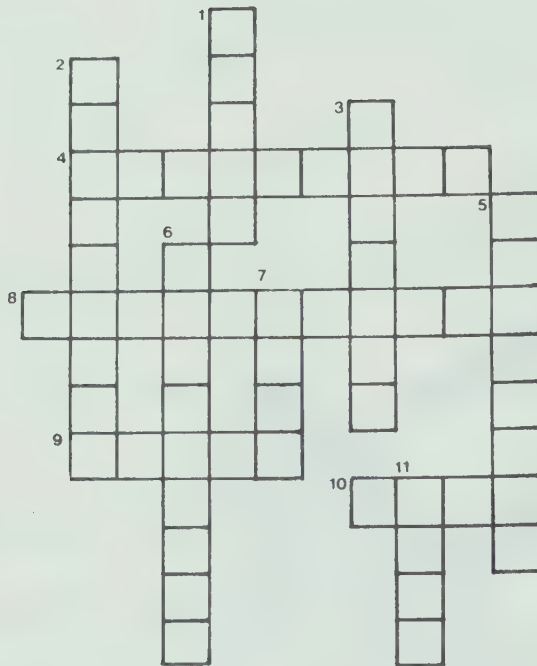
Self-test: Select the best answer

1. The glands around the hair follicles are
 - a) sebaceous glands
 - b) sweat glands
 - c) salt glands
 - d) None of these answers is correct.
2. The pigment which causes skin to have colour and to tan is
 - a) keratin
 - b) hemoglobin
 - c) melanin
 - d) bile
3. The layer of skin that contains specialized nerve endings is the
 - a) epidermis
 - b) dermis
 - c) subdermal layer
 - d) stratum corneum
4. Sweat glands are found in the greatest numbers on the
 - a) neck
 - b) palms of the hands
 - c) chest
 - d) scalp
5. The part of the skin that produces new cells is called the
 - a) epidermis
 - b) dermis
 - c) stratum corneum
 - d) stratum germinativum
6. Which of the following skin problems is not associated with glands in the skin?
 - a) acne
 - b) blackheads
 - c) warts
 - d) dry skin
7. Which of the following is not a function of the skin?
 - a) temperature control
 - b) production of vitamin D
 - c) excretion
 - d) respiration
8. Blushing is caused by
 - a) dilation of blood vessels in the skin
 - b) an emotional stimulus
 - c) hemoglobin that gives colour to the skin
 - d) All of these answers are correct.
9. Which of the following is a true statement concerning an emergency involving severe cold?
 - a) Avoid moving; stay in a shelter and huddle down.
 - b) Avoid cold moving air; stay in a sheltered position.
 - c) Keep wet clothing on; you will be warmer as the clothing dries.
 - d) Try to sleep; you will use less energy and therefore keep warmer.
10. Which of the following statements is false?
 - a) Men and women have about the same number of hairs on their bodies.
 - b) Hairs act as sensory organs.
 - c) Haircutting causes no pain as there are no nerve endings associated with hairs.
 - d) Hairs are continually being shed and replaced.

The Structure of the Skin



Crossword



DOWN

1. one of the five senses; recognized through the skin (5 letters)
2. a type of oil gland
3. substance that hardens and waterproofs the skin cells
5. a type of stimulus that can be sensed with the fingertips
6. the outer layer of skin
7. base of hair
11. a skin condition that often troubles teenagers

ACROSS

4. formed in oil glands when their secretions become oxidized
8. when skin capillaries dilate or constrict, they help to control this
9. a type of gland found on the palm of the hand
10. extends from follicles in the skin

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. a) | 6. c) |
| 2. c) | 7. d) |
| 3. b) | 8. d) |
| 4. b) | 9. b) |
| 5. d) | 10. c) |

ANSWERS TO CROSSWORD

DOWN

- 1. touch
- 2. sebaceous
- 3. keratin
- 5. pressure
- 6. epidermis
- 7. root
- 11. acne

ACROSS

- 4. blackhead
- 8. temperature
- 9. sweat
- 10. hair

LABEL ANSWERS FOR "THE STRUCTURE OF THE SKIN"
(Taken from Figure 3.1, text page 60)

- | | |
|----------------------------------|-------------------------------|
| 1. hair | 9. fat cells |
| 2. epidermis | 10. pain sensor |
| 3. opening of sweat gland (pore) | 11. capillaries/blood vessels |
| 4. dermis | 12. heat sensor |
| 5. pressure sensor | 13. hair follicle |
| 6. sebaceous oil glands | 14. arrector muscle |
| 7. sensory nerves | 15. stratum germinativum |
| 8. cold sensor | 16. stratum corneum |

Additional Resource Material

EXPOSURE TO SEVERE COLD

If you are called upon to help someone who has been exposed to severe cold - such as immersion in very cold water after falling through thin ice on a lake - then more extensive measures may be required. If the victim is conscious, talking clearly and sensibly, it is probably sufficient to get the person dry,

provide hot drinks, and provide general warmth. However, if the victim is unconscious or showing signs of slurred speech, drastic action must be taken immediately. If the accident occurs near a home, hot baths should be used. If possible keep the person's arms and legs out of the water so that the trunk of the body is warmed first. The water should be about 21°C initially; this should then be raised to approximately 43°C over a period of 10 min. Hot towels may also be used.

Medical attention should be obtained as soon as possible. If these methods are not possible, the rescuer should remove his or her own clothing and cover both the victim and himself or herself, ensuring that as much body contact is maintained as possible. Once the victim recovers consciousness and is talking sensibly again, the general principles suggested under the preceding section should be employed until medical help can be obtained.

Selected Readings

1. Hyde, Margaret, *Your Skin* (New York: McGraw-Hill, 1970).
2. Kessell, Richard and R. Kardon, *Tissues and Organs - A Text-Atlas of Scanning Electron Microscopy* (San Francisco: Freeman and Co., 1979).
3. *Medical and Health Annual* (Chicago: Encyclopedia Britannica, 1980).
4. Nilsson, Lennart, *Behold Man - A Photographic Journey inside the Human Body* (Boston: Little, Brown, and Co., 1973).
5. Silverstein, Alvin and V. Silverstein, *The Skin* (Englewood Cliffs, N.J.: Prentice-Hall, 1972).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Regulation of Body Temperature." 21 min col., EBE
2. "Man in Cold Water." 30 min col., Media and Technical Services, University of Victoria, B.C.
3. "You Can Do Something about Acne." Macmillan
4. "By Nature's Rules." (hypothermia). 20 min col., Omega Films

FILMSTRIPS

1. "The Skin and Its Functions." Visual Education Centre Canada Ltd., EBE
2. "Taste, Smell, Touch." Visual Education Centre Canada Ltd., EBE

TRANSPARENCIES

1. "The Integument." Wards Transparencies. Arbor Scientific, Ont.

Unit III

How the Body Is Supported and Moves

Chapter 4

Bones and Joints

Chapter Focus

It is more important to stress the functions of the skeletal system than to memorize the names of bones. Discuss the general structure and function of bone and use specific bones as examples. Do this with the joints as well; a thorough understanding of how one joint works, using a specific joint as an example, is all that is necessary. Terms describing bones are often difficult to say, spell, and remember, and they add little to the student's understanding. Use terms sparingly and only when necessary, and request a few specific examples to illustrate answers on test questions.

Athletic injuries, bone stress, and distortion should be discussed. In every class there will be students with skeletal and joint problems. Use these to illustrate that, although the body is very flexible and adaptable, there are limits. Damage to bones and cartilage can limit the individual's activity for life, or result in considerable long-term discomfort.

Good posture and the problems that can result from poor posture are subjects related to this topic.

Objectives

After studying this chapter, the student should be able to

- list the general functions of the skeletal system
- describe the structure of bone
- describe how bone is formed
- be familiar with the axial and appendicular skeleton
- be able to label specified major bones on a diagram of the skeleton
- be familiar with the parts of the skull and recognize the major features of the skull, such as suture lines, turbinates, foramen magnum, and the occipital condyles
- list the parts of the vertebral column, recognize the value of bursae and having many small bones rather than one long bone in the vertebral column
- explain why the body is subject to lower back pain and what the inherent weaknesses in the vertebral column are
- list the types of joints and explain their workings
- differentiate between bone, cartilage, ligaments, and tendon
- be familiar with skeletal injuries and diseases

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Skeletal System	*	
Functions of the Skeletal System	*	
The Structure of Bone	*	
Bone Formation		*
The Skeleton	*	
The Bones of the Skull		*
The Vertebral Column	*	
The Pelvis	*	
The Lower Limbs	*	
The Upper Limbs	*	
The Joints	*	
Skeletal Injuries and Disease		*

Teaching Suggestions

A short introduction on comparative anatomy is an interesting way to start this section on the skeletal system. Most laboratories have a few examples of animal skeletons: a cat, snake, bird, frog, a model of a dinosaur from a plastic kit, etc. The skeletons have much in common: the similarities between the vertebrae of all of these animals is outstanding. Similarities and differences in the number and shape of the bones of the limbs is noticeable. The variations in the rib cage and the pelvic girdle are also of interest to students and help them to recognize the strengths and weaknesses that are built into the human skeleton. This is especially important in explaining the weakness present in the lumbar region of the spine.

A full-size human skeleton is a great help in this section, but if this is not available, teachers may find other mammalian skeletons to be of some help. "Normal" or outdated X-rays may be obtained from hospitals or a radiologist at an X-ray clinic. The Red Cross or St. John's Ambulance are often willing to send a member of their staff to visit the classroom and provide help in first aid instruction.

Students should have an opportunity to observe dry bone slide sections under the microscope and to recognize Haversian canals and the structure of this tissue. Beef bones from a butcher can be cut on a band saw to provide cross and longitudinal sections of bones for examination.

The worksheets provided in the text and in this guide provide a useful approach to the study of the skeletal system. X-rays that illustrate suture lines, fractures, and implanted metal parts are also of great interest to students. Metal rods, hip replacements, and screws, used to hold bones together, show up well on X-rays.

Naming the bones of the skull is of limited value in high school except for identifying special areas and the location of the more important structures in relation to their functions.

The articulation of a joint can be demonstrated on the human skeleton, but a model that also shows the tendons, cartilage, ligaments, and muscles is clearer to the student.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 110)

- | | |
|-----------------|-------------------|
| 1. tendon | 6. suture |
| 2. articulation | 7. cervical |
| 3. vertebrae | 8. synovial fluid |
| 4. atlas | 9. ligament |
| 5. mandible | 10. cartilage |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 111)

- Functions of the skeletal system: provides structural support, protection of some organs, attachment for muscles, storage of minerals, manufacture of blood cells.
- The vertebral column consists of twenty-four separate bones plus the sacrum and coccyx. Divisions are
 - cervicals (neck) 7 bones
 - thoracic (chest) 12 bones
 - lumbar (small of back) 5 bones
 The sacrum is a single bone of five fused vertebrae, and the coccyx consists of three to five fused bones.

3.

AXIAL	APPENDICULAR
cervical vertebrae	humerus
skull	clavicle
temporal bone	radius
sacrum	
atlas	
mandible	

- | | |
|------------------|--------------------|
| Shoulder blade | - scapula |
| Breast bone | - sternum |
| Jaw bone | - mandible |
| Spine | - vertebral column |
| Thigh bone | - femur |
| Bones in forearm | - radius, ulna |
| Collar bone | - clavicle |
- spinal cord
 - middle and inner ear
 - heart and lungs
 - tendons and knee joint
 - lower abdominal organs including ovaries and uterus

6. The joint articulates with another bone to permit movement in one or more planes of motion.
7. Refer to Figures 4.22 and 4.23, pages 106 and 107 of the text.
8.

a) pivot	d) angular/pivot
b) ball and socket	e) hinge
c) gliding	f) fixed, little movement (flexible cartilage)
9.
 - a) the opening in the skull to allow the spinal cord to attach to the brain
 - b) junctions of sutures in the skull
 - c) part of the hard palate and bears teeth of the upper jaw
 - d) articulates with the humerus and distally with the carpals
 - e) articulates with the atlas and the third cervical vertebra
 - f) lies anteriorly along the midline from the region outside the diaphragm to the region between the clavicles, with ten pairs of ribs attached to it
 - g) five digits consisting of fourteen bones, two in the thumb and three in each of the other four digits
10. The most prominent difference in male and female skeletons is in the size of the pelvis. The subpubic angle is greater in the female allowing for the birth canal.
11. A simple fracture does not pierce the skin, whereas a compound fracture has the bone pushing out through the skin.

Text Activities

ACTIVITY 1: THE PROPERTIES OF BONE (TEXT, PAGE 112)

MATERIALS

two long, thin uncooked bones (ribs), 15% HCl, Bunsen burner, crucible, ring stand and support, clay triangle, large beaker

ACTIVITY OBJECTIVES

1. to demonstrate the function of the inorganic material in bone
2. to show the flexibility of bone when these inorganic materials are removed
3. to demonstrate the properties of the organic material in bone

PREPARATION TIPS

This exercise could be conducted as a teacher demonstration. Heating should be carried out in a fume cupboard. The bones treated in acid may be freely bent or twisted into a knot after all the inorganic calcium carbonate and phosphates are removed. Figure 4.1 and 4.3 show the general features of bone

tissue. The thin membrane is the periosteum, which contains blood vessels, nerves, and bone-forming cells. Bone consists of about 65% inorganic substances, mainly calcium phosphate, and 35% organic substances of dense protein known as collagen. The collagen fibres bind to calcium phosphate. The binding substance is manufactured by bone cells (osteocytes). Heating will destroy the matrix of protein substances, leaving behind the inorganic material. To prepare 15% HCl solution, add about 50 mL HCl to 450 mL water.

ACTIVITY 2: DO THE SPINE OR THE LEGS HAVE GREATER INFLUENCE IN DETERMINING OVERALL HEIGHT? (TEXT, PAGE 112)

ACTIVITY OBJECTIVES

1. to demonstrate that variations occur in bone length
2. to show that students of equal heights may vary in the length of the legs
3. to increase students' awareness of variations in the human body and the uniqueness of their own bodies

PREPARATION TIPS

Students should remove their shoes and stand upright to obtain their heights. A flat object placed on top of the head provides some degree of accuracy in measuring. Students should sit upright with their backs vertical to the backrest of their chair (or, better still, sit on a bench against the wall) to have their heights recorded when seated. The length of the legs is generally a major factor in deciding the height of an individual. Results may not be consistent!

ACTIVITY 3: USING YOUR TEXT, A SKULL, AND THESE DIAGRAMS, ANSWER THE FOLLOWING QUESTIONS IN YOUR NOTEBOOK. (TEXT, PAGE 113)

Answers to questions 1-14.

- | 1. <u>ANTERIOR VIEW</u> | <u>LATERAL VIEW</u> | <u>INTERIOR VIEW</u> |
|-------------------------|-----------------------------|----------------------|
| a) frontal | a) frontal | a) zygomatic process |
| b) parietal | b) parietal | b) occipital condyle |
| c) temporal | c) temporal | c) occipital |
| d) zygomatic arch | d) occipital | d) foramen magnum |
| e) maxilla | e) zygomatic arch | e) hard palate |
| f) mandible | f) external auditory meatus | |
| | g) mastoid | |
| | h) condyloid process | |
| | i) mandible | |
| | j) maxilla | |
2. The frontal bone protects the eyes from large objects. It forms the large arches over the eye sockets. The frontal bone acts as a buffer, joining the parietal and temporal bones to protect the brain.

3. suture
4. To allow for expansion and growth of the brain, and easier delivery.
5. The occipital bone protects the brain and allows the skull to articulate with the atlas.
6. The auditory (acoustic) meatus allows sound vibrations to reach the inner ear.
7. mandible
8. atlas
9. spinal cord
10. The eye socket is in fact composed of three bones: the frontal bone, zygomatic arch, and the maxilla. These bones appear anterior to the actual eye and resist large objects.
11. The openings provide a passage for the optic nerve and blood vessels.
12. There is a fused ridge on the inner anterior side of the mandible.
13. maxilla
14. Ear ossicles are found in the temporal bone.

Additional Activities

ACTIVITY 4.A: THE RELATIONSHIP BETWEEN THE STRUCTURE AND THE FUNCTION OF BONES (AN OBSERVATIONAL EXERCISE)

MATERIALS

In these exercises you should refer to as many different study materials as possible. The following will be useful aids: a human skeleton, a mammalian skeleton (such as that of a cat), models, films, slides, books, and X-ray prints. First review the functions of the skeleton. Keep these in mind as you study the SHAPES, POSITIONS, and the ARTICULATIONS of the bones. If your laboratory has skeletons of vertebrates, such as the cat, frog, fish, snake, or even a plastic model of the skeleton of a dinosaur, try to compare these skeletons. You will be surprised how many similarities they possess.

THE VERTEBRAL COLUMN. Refer to Diagram A.

1. Compare the vertebrae of as many skeletons as are available. (Pictures will help.)
2. What general shape do all the various vertebrae possess? How do they differ?
3. What advantages does an animal with a backbone possess?
4. Use the diagram sheet and list the names of each section of the vertebral column.
5. An infant's spine has 33 bones but the adult spine has fewer than this. Explain the difference.
6. Draw a simple outline sketch of the spine of a baby when in the fetal position (curled up). Draw, beside this, the spinal curves of an adult.
7. As a baby first begins to lift its head, what new curve is gradually acquired?
8. As a baby starts to walk, what second curve is added?
9. Which way does the baby fall when it is learning to walk - forward or backward? Why?
10. What weakness is almost always present in the human spine? Why?

THE VERTEBRAE. Refer to Diagram B and C.

1. What are the names of the two bones marked a and b in Diagram B?
2. What is the function of each? What features in the shape of these bones aid their function?
3. What passes through the openings in each of these bones? (A similar opening is present in Diagram C at a.)
4. What bone is in contact with the articular surface in Diagram C?
5. Examine the thoracic vertebrae of the skeleton and Diagram C. What articulates with the surfaces marked b? What articulates at c? Be sure to examine the skeleton to confirm your answer.
6. Refer to Figure 4.12, page 98 in the text, and explain why it is easy to

continued . . .

bend forward and difficult to bend backward. Confirm this by checking the skeleton.

7. Carefully examine the posterior aspect of several vertebrae and describe what prevents the vertebrae from sliding from side to side and keeps the vertebrae in line.
8. Which of the vertebrae is the largest? Why would this be so?
9. Of what value are the two winglike projections on each vertebrae?
10. If you have a plastic model of a dinosaur skeleton, examine the posterior processes, which stick out at the back of each vertebrae, and compare them with those on the human skeleton. How are they similar? How are they different?

THE RIBS AND UPPER LIMBS. Refer to Diagram D.

Refer to X-ray prints as well as a skeleton for this section.

1. How many pairs of ribs are attached in some way to the sternum?
2. How many pairs of ribs are free and unattached at the front?
3. Note the articulation at each end of the ribs. Describe by what means the ribs are attached to i) the vertebrae, ii) the sternum.
4. What is the material marked i in the Diagram D. Describe the nature of this material and how this type of structure facilitates the action of the ribs in breathing.
5. Note how far into the cavity the vertebral column projects. (Refer to Figure 4.9a, page 96, and Figure 4.13, page 99, in the text.) What organs are contained in the thoracic cavity?
6. Identify the bones lettered in Diagram D. How is the scapula attached to the rest of the skeleton? With what bones does the scapula articulate? Feel your partner's scapula while he or she rotates an arm. What do you notice? Do any other bones in the body have this mobility?
7. What bones form the shoulder joint?
8. Describe the joints at the shoulder, the elbow, and the wrist. Note the shape of the bones. How does the shape of the bones dictate whether the joint moves like a hinge or have the ability to rotate completely?
9. Identify the radius bone. Compare the action of the skeleton with the rotation of your own arm. Rotate the hand of the skeleton and your own hand. Describe the action of the radius in making this movement.
10. What role does the ulna play?
11. Examine the bones of the fingers. Why can we only curl and straighten the fingers and not rotate them or bend them sideways?

THE PELVIS AND LOWER LIMBS. Refer to Diagram E.

1. Examine the hip joint. Why doesn't the hip joint fall out of its socket in the pelvis?
2. What is a sprain?
3. Does the pelvis have a rigid articulation with the sacrum?
4. Of what value is the cartilage that is inserted in the front of the pubis?
5. Examine the bones of as many skeletons as you can. Compare the number of bones in the forelimbs and the general shape and location of these bones.
6. Compare the hind limbs, the skulls, or pelvic bones and see how many similarities you can discover. Can you give any explanations for the many similarities and dissimilarities?

Diagram A

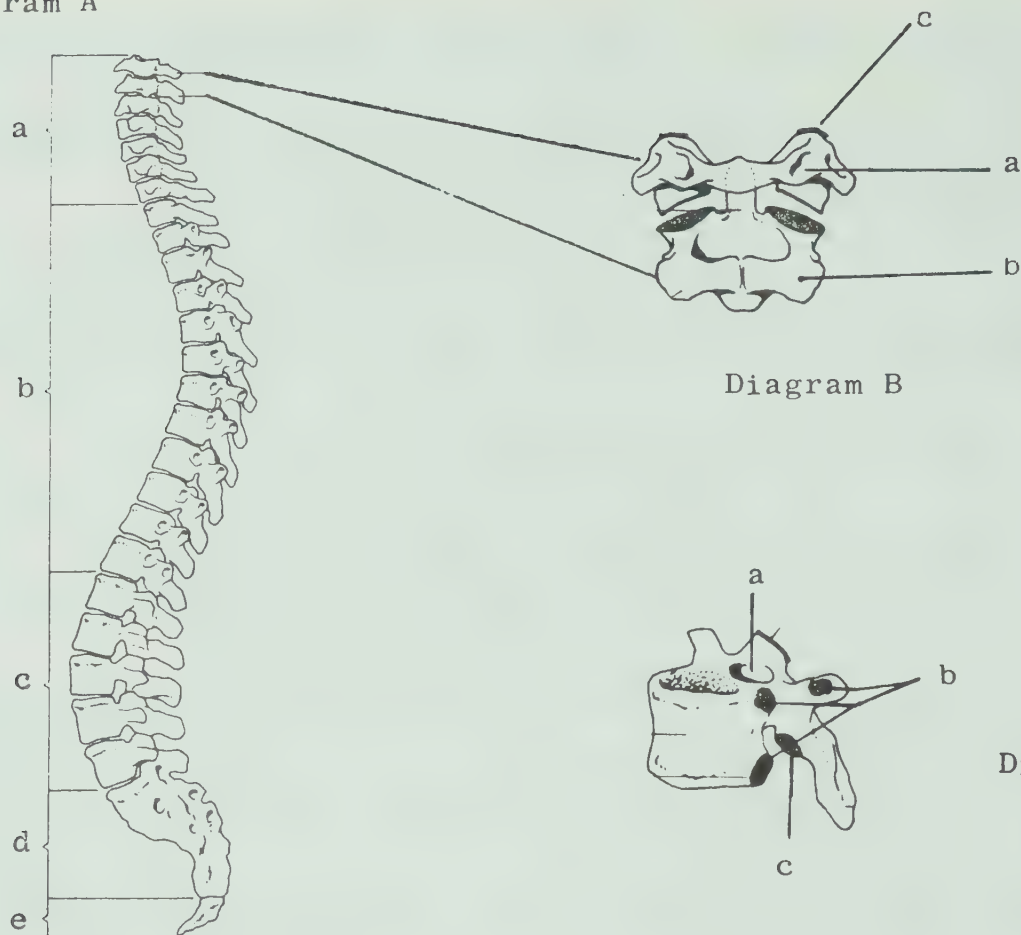


Diagram B

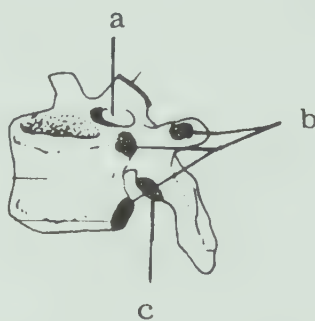


Diagram C

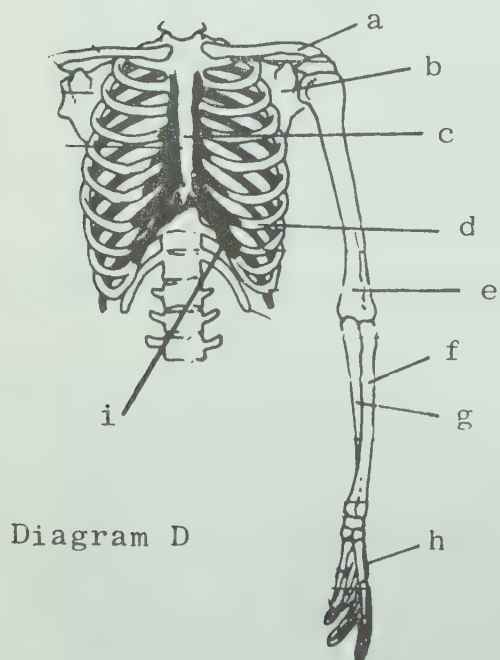


Diagram D



Diagram E

Figure: Illustrations for observational exercise Activity 4.A.

ANSWERS TO QUESTIONS

Vertebral Column

1. If various animal skeletons are available, vertebral column modifications can be observed.
2. Most vertebrae resemble each other in possessing a round drum-like body, processes (a spinous and two lateral or transverse and articulating processes), and an opening for the spinal cord. The positioning of the spinous processes changes for each vertebra.
3. An animal with a backbone has the following advantages: protection of the spinal cord and nerves, the ability to support mass, and the ability to move more effectively.
4. Note that the first cervical vertebra is the atlas. Then there is the axis. There are 7 cervical, 12 thoracic, 5 lumbar, 5 fused sacral vertebrae, and 4 fused coccyx bones.
5. There is fusion of the bones of the coccyx.
6. Refer to Figure 4.2, page 87, of the text. In the baby, there is only one curve, similar to that of the cat. In the adult, several curves develop due to upright posture. See Figure 4.13, page 99, in the text.
7. Cervical or neck curve. See Figure 4.13, page 99, in the text.
8. Thoracic or chest curve followed by the lumbar or curve in the small of the back.
9. The infant falls on its buttocks since the lower vertebral column is not curved. See Figure 4.13, page 99, in the text.
10. Weakness of the ligaments and support muscles in the lumbar region are due to factors such as the upright posture, a sedentary way of life, poor posture, and pregnancy.

The Vertebrae

1. a) Atlas (first cervical) and b) axis (second cervical).
2. The atlas articulates with the condyles of the skull and supports the skull. It effects the up and down movement of the skull. The axis articulates with the atlas and third cervical, and effects side-to-side movements of the skull.
3. Spinal cord.
4. Refers to the articular facets where the rib attaches to the vertebra.
5. Refer to Figures 4.8, page 94, and 4.9a and 4.9b, page 96 of the text.
 - b) rib
 - c) vertebra

6. The spinal processes impede backward movement, but forward movement opens the spaces between the posterior processes.
7. The lumbar vertebrae are very heavy and have articulating processes that are vertically oriented to support most of the mass of the upper body. Small ridges of bone overlap to prevent side-to-side movement.
8. Vertebrae in the lumbar region are the largest where greater mass is supported.
9. On the thoracic vertebrae, these aid in attachment of the ribs. Muscles and ligaments are attached to these processes on all vertebrae.
10. The general shape is similar, but in many dinosaurs the process is greatly extended to form the great bony fans on the animals' backs.

The Ribs and Upper Limbs

1. 10 pairs.
2. 2 pairs.
3. i) 12 pairs of ribs attach on each pair of facets on each vertebra (4 facets per vertebra).
ii) Cartilage binds the first 7 pairs to the sternum. The next three are attached by cartilage to the rib above. The lower two are not attached at the front.
4. Cartilage. (See Figure 4.9b, page 96, in the text.) Cartilage is flexible and elastic; it supports the lungs and heart, and allows for small movements of the rib cage during respiration.
5. The lungs and heart.
6. The scapula is attached by muscles and ligaments to the ribs, and articulates with the clavicle and the humerus. Check against Figure 4.9b, page 96, in the text. The scapula is free to move as you rotate your arm. The hip has limited mobility. The scapula is the only bone to be so loosely attached.
7. The shoulder joint is formed by the articulation of the scapula, clavicle, and the head of the humerus.
8. Shoulder joint - ball and socket
Elbow joint - hinge joint
Wrist - gliding joint
The degree or kind of movement is due to the type of joint, strength of each joint, and the degree of closeness of the bony parts and ligaments.
9. The radius rotates over the ulna as seen in Figure 4.19, page 103, in the text.
10. The ulna is the main supporting bone, which articulates proximally with the humerus and distally with the carpals.

11. This is a hinge joint like the knee, elbow, and ankle with a back and forth movement.

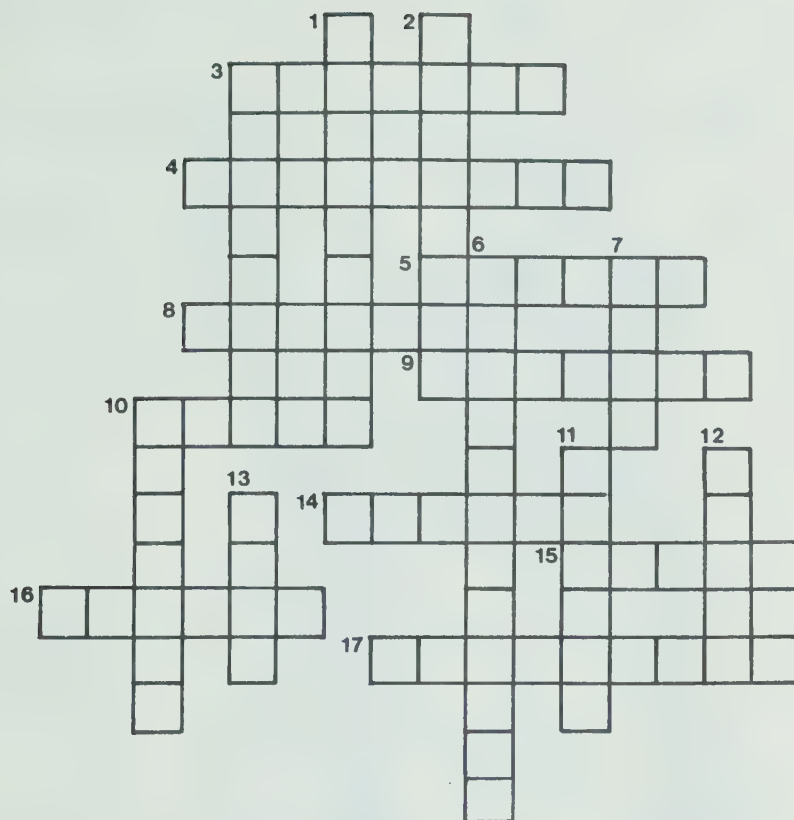
The Pelvis and Lower Limbs

1. The hip joint possesses a deep socket, a collar of cartilage, and ligaments, which aid in retaining the head of the femur within the socket.
2. A sprain results from the temporary separation of the bones and the stretching or tearing of ligaments. Tendons and muscles are also affected.
3. The sacrum articulates closely and fuses with the pelvis.
4. The cartilage at the pubic symphysis allows slight movements and absorbs shock because most of the weight of the body is centred in the pelvis region. It allows some movement of the pelvis during the delivery of a baby.
5. Answer depends on other skeletons observed.
6. For this exercise students could compare the kinds of joints and movements.

Self-test: Select the best answer

1. Bones are attached to other movable bones by
 - a) tendons
 - b) ligaments
 - c) cartilage
 - d) gristle
2. The part of the spine found in the neck is known as
 - a) thorax
 - b) lumbar region
 - c) cervical region
 - d) sacral region
3. Which of the following is not a function of bone?
 - a) storage of minerals
 - b) production of red blood cells
 - c) protection of internal organs
 - d) production of melanin
4. Which of the following is not an example of a long bone?
 - a) humerus
 - b) sternum
 - c) femur
 - d) radius
5. The axial skeleton consists of the
 - a) skull, vertebral column, and ribs
 - b) skull, vertebral column, and pelvis
 - c) vertebral column and pelvis
 - d) skull, vertebral column, ribs, and pelvis
6. Which of the following statements concerning the lower jaw is incorrect?
 - a) It is known as the mandible.
 - b) It moves when chewing and talking.
 - c) It is held in place by ligaments and muscles.
 - d) It is known as the maxilla.
7. Which of the following bones articulates with the humerus?
 - a) clavicle
 - b) scapula
 - c) radius
 - d) All of these answers are correct.
8. Haversian canals
 - a) carry blood within the bones
 - b) refers to the bone marrow
 - c) carry nerves within the bones
 - d) are the site of red blood cell production
9. The opening (foramen) in each vertebrae
 - a) contains the spinal cord
 - b) carries the aorta
 - c) contains a bony pivot that links one vertebra with another
 - d) is filled with cartilage to absorb shocks to the spine
10. The bones of the skull are not fused at birth because
 - a) this allows movement of the bones to adjust to the size of the birth canal during labor
 - b) this allows room for the brain to grow and expand
 - c) Both a) and b) are correct.
 - d) Both a) and b) are incorrect.

Crossword



DOWN

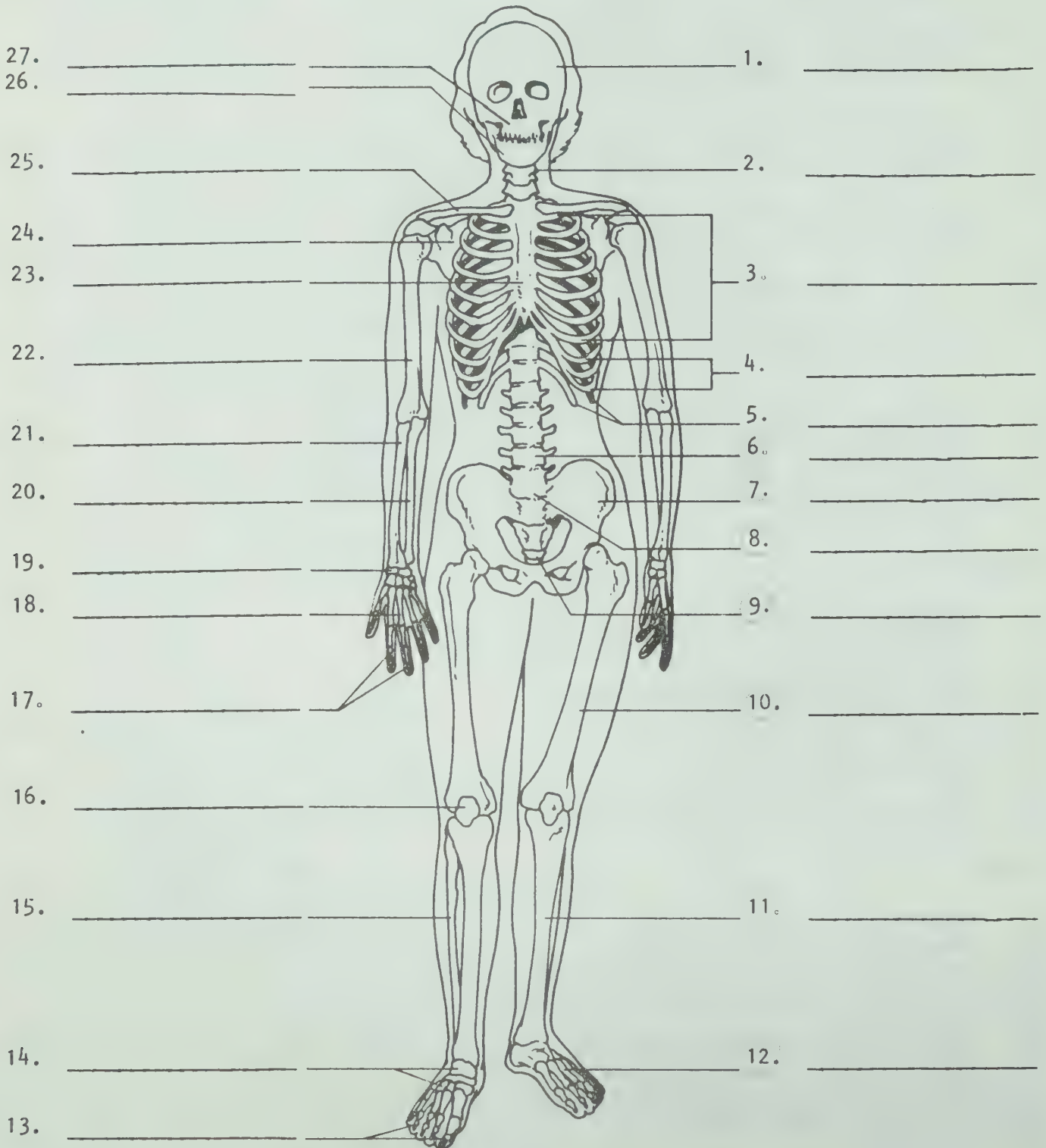
1. flexible supporting tissue
2. region of the spine in the lower back (6 letters)
3. total bone framework
6. when one bone moves against another
7. a bone in the forearm
10. bone in the upper arm
11. attaches muscle to bone
12. type of joint between the atlas and axis vertebrae
13. second bone of the vertebral column

ACROSS

3. shoulder blade
4. single bone of the spine
5. a bone in the forearm that turns the hand
8. bone that supports the skull (5 letters)
9. breast bone
10. type of joint found at the elbow
14. line where two fused bones meet
15. type of cell that transports impulses
16. a temporary dislocation
17. a bone cell

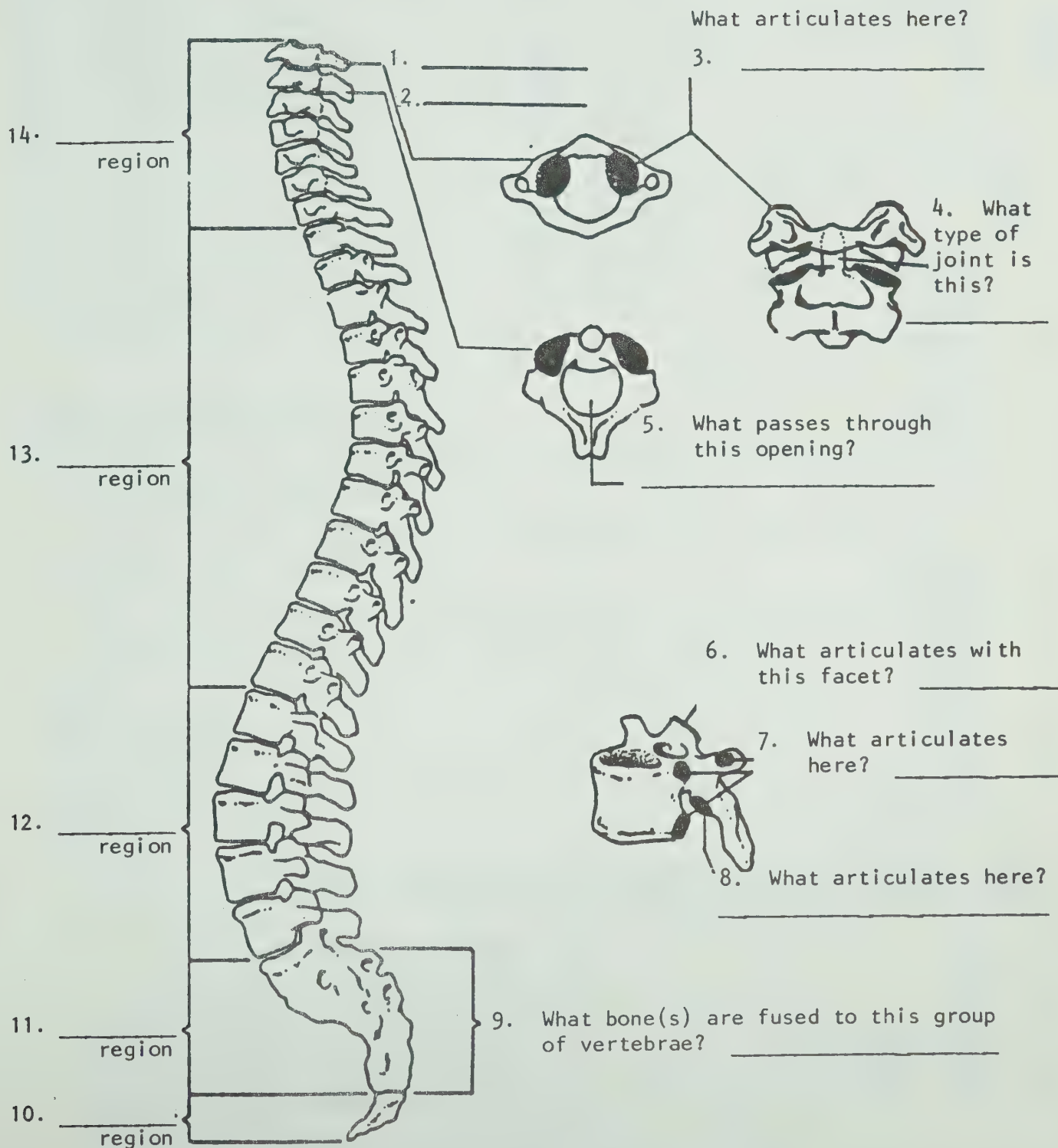
The Major Bones of the Skeleton

Fill in the blanks with the correct labels.



The Bones of the Vertebral Column

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. d) |
| 2. c) | 7. d) |
| 3. d) | 8. a) |
| 4. b) | 9. a) |
| 5. d) | 10. b) |

ANSWERS TO CROSSWORD

DOWN

1. cartilage
2. lumbar
3. skeleton
6. articulates
7. ulna
10. humerus
11. tendon
12. pivot
13. axis

ACROSS

3. scapula
4. vertebrae
5. radius
8. atlas
9. sternum
10. hinge
14. suture
15. nerve
16. sprain
17. osteocyte

LABEL ANSWERS FOR "THE BONES OF THE VERTEBRAL COLUMN"
(Taken from Figure 4.8, text page 94)

- | | |
|----------------------|---------------------|
| 1. atlas | 8. vertebra below |
| 2. axis | 9. pelvic bones |
| 3. skull | 10. coccyx region |
| 4. pivot | 11. sacral region |
| 5. spinal nerve cord | 12. lumbar region |
| 6. vertebra above | 13. thoracic region |
| 7. rib | 14. cervical region |

LABEL ANSWERS FOR "THE MAJOR BONES OF THE SKELETON"

(Taken from Figure 4.4, text page 89)

- | | |
|-----------------------|----------------|
| 1. cranium | 15. fibula |
| 2. cervical vertebrae | 16. patella |
| 3. true ribs | 17. phalanges |
| 4. false ribs | 18. metacarpal |
| 5. floating ribs | 19. carpals |
| 6. lumbar vertebrae | 20. ulna |
| 7. pelvis | 21. radius |
| 8. sacrum | 22. humerus |
| 9. coccyx | 23. sternum |
| 10. femur | 24. scapula |
| 11. tibia | 25. clavicle |
| 12. metatarsals | 26. mandible |
| 13. phalanges | 27. maxilla |
| 14. tarsals | |

Selected Readings

1. Copenhauer, W. M. *et al.*, *Bailey's Textbook of Histology* (Baltimore: Williams and Wilkins, 1971).
2. Vaughan, J. M., *The Physiology of Bone* (New York: Oxford University Press, 1975).
3. White Knox, A. C., *A Preliminary Manual of First Aid for Young Canadians* (Great Britain: St. John's Ambulance Assn., 1971).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

FILMSTRIP

1. "The Skeletal System." Visual Education Centre, Canada

FILMLOOPS SUPER-8 mm WARDS

1. "Spinal Column - Axis of the Skeleton."
2. "The Knee Joint."
3. "The Shoulder Joint."
4. "Bad Posture."
5. "Treatment for Broken Bones." National Scientific Products Corp. - Eye Gate Media
6. "Dislocations and Sprains." National Scientific Products Corp. - Eye Gate Media

Chapter 5

Muscles

Chapter Focus

Stress the general function and structure of muscles and their ability to contract and relax. Use the same approach as was suggested for the skeletal system: limit the memorization of names of muscles to a few examples that illustrate muscle action. Charts are provided for reference, but not as lists for memorization.

Attachment to muscles and how tendons allow movement around the constricted areas of joints are important. Worth stressing is the mechanical disadvantage of muscle attachment, which, on the other hand, improves mobility. A few simple examples to show the enormous forces required to move relatively small loads is impressive.

Relate the study of the activity of muscles to activities that the students regularly perform. Academic discussion, divorced from practical applications, has limited value to the student.

Objectives

After studying this chapter, the student should be able to

- differentiate between the terms skeletal, smooth, and cardiac muscle
- be able to describe the differences in structure between these muscle types
- give examples of some common muscles
- explain how muscle contraction and extension works
- differentiate between isometric and isotonic contraction
- explain the need for antagonistic pairs of muscles
- describe how muscles are attached and know the meaning of the terms "origin" and "insertion"
- list examples of bones that act as different classes of levers
- explain the general cause of muscle fatigue
- list the advantages of good posture
- know the terminology of muscle movements

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Muscular System	*	
Muscle Contraction and Extension	*	
How Muscle Cells Contract	*	
The Stimulation of Muscle Contraction		*
Isometric and Isotonic Contraction		*
Antagonistic Pairs of Muscles	*	
Muscle Attachment	*	
Tendons	*	
Muscles in Action	*	
Muscle Fatigue and Energy Needs		*
Muscle Tone and Posture		*
Describing Muscle Movement		*
Muscle Disorders		*

Teaching Suggestions

The discussion of isometric and isotonic muscle contraction leads naturally to a discussion of good posture. Many students have adopted poor posture habits, and this adversely affects their self-images and the picture they present to others. A good working relationship with the physical education staff can provide a useful and profitable partnership for the benefit of the students. Advice on suitable exercises to improve muscle control of the abdominal muscles, for example, would be valuable and can be tailored readily to individual needs.

Teachers may wish to warn students of the dangers of exercise that is poorly supervised or directed. Students who take up exercise programmes, especially strenuous ones such as weight-lifting, should work out with well-qualified instructors. Many physicians are reporting an increased number of patients who are coming for treatment of disorders that could easily have been avoided with good professional athletic advice.

Teachers may wish to use the rat, fetal pig, or other mammal for the study of anatomy. There are various dissection guides that could be used. Some of these guides may be too advanced, so only some of the material should be selected. The *Fetal Pig Guide* by Warren Walker (W. H. Freeman & Co.) and *Laboratory Anatomy of the White Rat* by Robert Chiasson (3rd ed., W. C. Brown Co.) are recommended. These guides are useful for studying all the major systems, beginning with the muscular system.

For the structure of muscles, good electron micrographs of the sarcomere and details of the myosin cross bridges are available from Carolina Biological. The 16 mm films listed under "Visual Aids" are of superior quality.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 128)

- | | |
|----------------|---------------|
| 1. involuntary | 6. flexion |
| 2. isotonic | 7. myofibril |
| 3. cartilage | 8. tendon |
| 4. origin | 9. isometric |
| 5. adduction | 10. voluntary |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 129)

1. Skeletal or voluntary muscles are attached to the skeleton and have striations.
Smooth or involuntary muscles are located around hollow organs and tubes in the body and are not under voluntary control.
Cardiac muscle is located in the heart. It is a type of combined involuntary and striated muscle.
2. Students could mention the role of man as hunter and his having well-developed skeletal muscles. Today man leads a mostly sedentary life. Certain lower and upper back muscles are not being used. Machinery has taken over the plough and the hoe, and manual labour is restricted. Man has moved from an agricultural base and from a rural to an urban way of life.
3. Antagonistic muscles act against each other to maintain isometric contractions. These muscles act against each other in order to provide support for the body. Examples are the biceps and triceps, and the external intercostals and internal intercostals.
4. Isotonic contraction effects shortening of muscles; with isometric contraction, there is no change in the length of the muscles.
5. "Origin" refers to the attachment of a muscle tendon to an immovable bone. When the other tendon of the muscle is attached to a movable bone, it is called the "insertion".
6. Good posture will lessen the incidence of backache and strain on the discs between vertebrae. It also reduces fatigue, improves circulation, and reduces the crowding of internal organs. (Students may wish to investigate basic kinesiology of postural concepts and principles.)
7. Tendons are strong connective tissue that attach the muscles to bones. Tendons pass over bony prominences, such as the elbow, that would distort a muscle as movement occurs.
8. Skeletal muscles are under the influence of nerve endings called "end plates", which release acetylcholine. This chemical release produces changes in the permeability of muscle cells to sodium ions. Muscles depolarize and contract.

Heart muscles and smooth muscles are under the influence of the autonomic nervous system and other inherent factors.

9. Muscles use bones as levers. The effort used by muscles to lift objects can be calculated on the principles related to the use of levers. When greater strength is required, more muscle cells are brought into action. Exercise increases the size of the muscle cells, but does not increase their number.
10. See Figure 5.3, page 119, in the text. Advanced students may wish to investigate the role of troponin, calcium, and tropomyosin in muscle contraction.

Text Activities

ACTIVITY 1: INVESTIGATING MUSCLES AND TENDONS (TEXT, PAGE 130)

MATERIALS

chicken legs, pithed frog or a freshly killed chicken with feet attached, dissecting tray, instruments, 1.5 V battery (optional)

ACTIVITY OBJECTIVES

1. to demonstrate the attachment of tendons to muscles
2. to show the arrangement and separation of muscles
3. to provide an opportunity to observe the nature of tendon and muscle tissue
4. to observe the antagonistic effects of flexors and extensors in muscles

PREPARATION TIPS

This activity could be a teacher demonstration. The pithed frog gastrocnemius muscle could be stimulated directly, or the sciatic nerve could be isolated and stimulated by the 1.5 V source to show the effect of contraction. Students could observe, with the hand lens or microscope, the point of insertion of tendons into the bone. Students should be able to recognize that the tendons are tough. The 16 mm films listed under "Visual Aids" are highly recommended.

ACTIVITY 2: EXAMINATION OF MUSCLES AND TENDONS (TEXT, PAGE 130)

ACTIVITY OBJECTIVES

1. to demonstrate the action of the gastrocnemius muscle and Achilles tendon
2. to observe the strength of the Achilles tendon
3. to draw a simple diagram showing the bones, tendons, and muscles of the foot

PREPARATION TIPS

The calf (gastrocnemius) muscle is attached to the gastrocnemius tendon, more commonly called the Achilles tendon. This tendon is inserted on the heel bone. The origin of the calf muscle arises from two strong tendons on the femur condyles. We keep our balance, move the foot up and down, run, jog, and dance with this powerful tendon and muscle. The movement of the foot upward causes the contraction of the tibialis anterior. The longus (extensor digitorum) muscle co-ordinates with the longus tendons to move the toes. Students should count up to five tendons in the front of the foot.

ACTIVITY 3: WHAT EFFECT DO LOW TEMPERATURES HAVE ON MUSCLE CONTRACTION AND CONTROL? (TEXT, PAGE 131)

ACTIVITY OBJECTIVES

1. to demonstrate the effects of low temperatures on muscle contraction
2. to show that muscle massage and warming will increase circulation and muscle activity

PREPARATION TIPS

Students could relate this exercise to throwing snowballs. The control and co-ordination of the fingers are partially lost. The muscles that move the fingers are from the humerus, ulna, and radius. Temporarily lost are the flexion (movement of the fingers toward you) and extension (movement of the fingers away from you), as well as the abduction (movement toward the thumb side) and adduction (movement toward the little finger side).

ACTIVITY 4: WHAT CHANGES TAKE PLACE IN MUSCLES WHEN THEY CONTRACT? (TEXT, PAGE 131)

ACTIVITY OBJECTIVES

1. to demonstrate how the biceps and triceps function
2. to show that the muscles and joints work on the same principles as levers do
3. to provide an understanding of the efficiency and strength of muscles, joints, and bones in lifting objects

PREPARATION TIPS

Your reference should be Figures 5.9 to 5.13 in the text. The Physics laboratory should be able to supply you with weights and metre sticks. A fulcrum could be used with metre sticks and weights to calculate the mechanical advantage of different classes of levers. The biceps act as a third class lever, with the elbow as the fulcrum. Refer to the text, page 125 and the answer to question 9, page 129. In this activity on the lever, the distance from force to fulcrum is the distance from the centre of the elbow to the tip of the elbow, which is about 3 cm. Third class levers, as well as first class levers, require great strength. This may seem to be inefficient, but the degree of movement achieved

by the muscles is greater, allowing for the movement of the hand. The distance from the fulcrum to the hand, where the load is placed, requires greater force. The shorter the forearm, the less the force required.

Additional Activities

ACTIVITY 5.A: THE EFFECT OF FATIGUE ON MUSCLES

MATERIALS

watch or clock with second hand

PART I METHOD

1. Draw a table in your notebook as shown here.

Trial	1	2	3	4	5	6	7	8	9	10
# of hand opening/ closings in 20 s										

2. Open your hand and close it again rapidly and forcefully. The fingers should be fully extended on opening and tightly curled on closing each time.
Count the number of times you can open and close your hand in 20 s.
Record the number of times in the table.
3. Repeat this action for 10 more trials; each trial must follow immediately after the other. Do not allow more than a few seconds between each trial.
Record your results in the table.
4. Plot your results on a graph using the trial numbers on the horizontal axis and the number of open/closing actions on the vertical axis.

QUESTIONS

1. Compare your graph with those of other students in the class. Is there a general similarity in the overall pattern of the graphs? Account for the variation in the results of the various trials.
2. Find out what muscles control the finger movements and where these muscles are located.
3. What sensations did you experience during and after the experiment? Indicate where these sensations were felt - in the hand, fingers, or arm. Explain why these sensations were experienced in each location.

PART II METHOD

Allow the hand to rest for several minutes.

1. Under the direction of your teacher, place a blood pressure cuff around

continued . . .

the upper arm; inflate the cuff until the wrist pulse can no longer be felt. The blood supply to the lower arm and hand has now been cut off.

2. Repeat the hand opening and closing movements as rapidly and forcefully as possible.
3. Count the number of times that you are able to do this in 20 s. Compare your results with the first trial in Part I. Release the cuff.
4. Record your results and the relationship between muscle fatigue and blood supply.

ACTIVITY OBJECTIVES

1. to show that muscle efficiency declines with fatigue
2. to improve data recording and graphing skills
3. to show students the location (forearm) of the muscles that move the fingers

PREPARATION TIPS

Results will vary across the class according to the effort made by the students to induce fatigue, the degree to which the hand is stretched open or tightly closed, and the hand strength of students (typists and piano players may show differing results).

The graphed results usually show an initial increase in the number of openings, followed by a significant decrease as the sudden and unexpected demand uses up the available energy in these muscles. There is then a gradual return to a high level of performance and a general fluctuation, by small amounts, toward the end of the experiment as determination falters.

The students should be questioned as to where pain occurs, what other sensations are felt (tingling), and where they are felt. They should be questioned also about the effects felt after a short rest time.

METHOD OF PITHING A FROG

Teachers should check for any provincial regulations regarding the use of live animals for experimental purposes in the laboratory. Any animals must be completely anaesthetized and free from pain before any experimentation is carried out. The following is the method of pithing a frog.

1. Grasp the frog firmly with one hand, placing the snout between the forefinger and the middle finger.
2. Press the head of the frog in a downward position.
3. Run a dissection needle at the midposterior region of the head, and locate a small depression, the foramen magnum, which is the junction between the skull and the first vertebra.
4. Insert the point of the needle at this position, moving it from side to side, in an up and down motion quickly.
5. When you are sure that the brain is completely destroyed, then proceed with your operation.

METHOD OF NERVE-MUSCLE PREPARATION

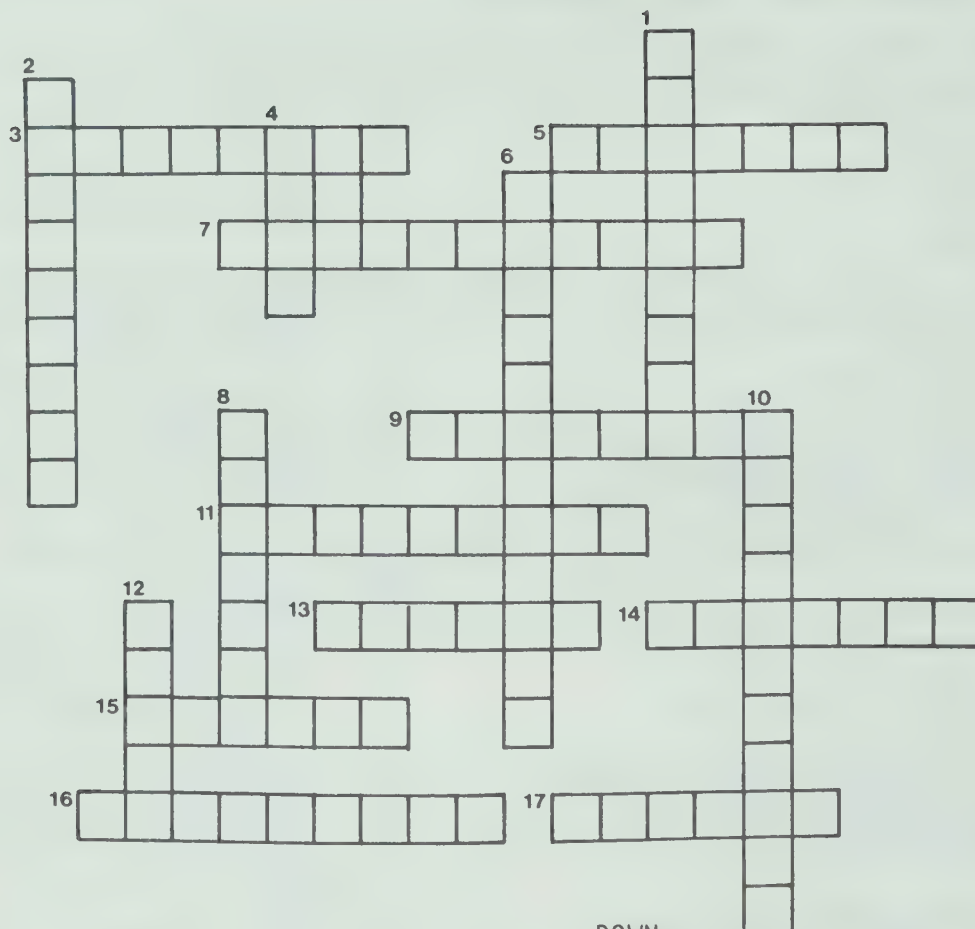
This method allows you to isolate the gastrocnemius muscle and the sciatic nerve. The procedure is as follows:

1. Remove the skin of the entire hind leg of a freshly pithed frog.
2. Locate the Achilles tendon. This attaches the gastrocnemius muscle to the foot.
3. Cut the Achilles tendon near the foot and the upper end of the muscle just below the knee joint.
4. Using a probe, locate the silver-white, string-like structure running along the region of the head of the muscle and the knee joint.

Self-test: Select the best answer

1. What type of muscle causes a contraction in the walls of the small intestine?
 - a) voluntary
 - b) involuntary
 - c) cardiac
 - d) striated
2. Which of the following is not a true statement?
Heavy muscular activity results in
 - a) increased body temperature
 - b) decreased body temperature
 - c) increased blood pressure
 - d) build up of lactic acid
3. Exercise produces
 - a) an increase in the number of muscle cells
 - b) an increase in the size of muscle cells
 - c) little change in muscle size
 - d) Exercise results in more cells being used.
4. Cardiac muscle tissue is recognized by cells that show
 - a) cigar-shaped cells with central nuclei
 - b) parallel fibres, striations, and nuclei along the side of the fibres
 - c) branched fibres with no striations and small discs
 - d) branched fibres, faint striations, and scattered nuclei
5. Muscle cells can
 - a) only contract
 - b) contract and relax
 - c) contract and extend to exert a push
 - d) partially contract and extend
6. Muscle cells are
 - a) easily replaced
 - b) not easily replaced
 - c) replaced with extra effort and exercise
 - d) None of the above is correct.
7. Striations are produced by
 - a) bands of pigment which reflect light
 - b) thin and thick filaments overlapping
 - c) overlapping myofibrils
 - d) discs within the muscles
8. A muscle is stimulated to contract when
 - a) acetylcholine is released in the muscle from the end plates
 - b) end plates in the muscle receive impulses
 - c) an impulse is received from the central nervous system
 - d) All of the above are correct.
9. An example of isometric contraction is
 - a) a boy standing in a doorway pushing sideways against the door posts
 - b) a girl standing upright with her head held erect
 - c) a tennis player running after a ball
 - d) Both a) and b) are correct.
10. Which of the following statements is not true concerning the contraction of the biceps muscle?
 - a) The insertion is drawn towards the origin of the muscle.
 - b) The terms "origin" and "insertion" refer to the attachment of the muscle and are not involved.
 - c) The origin of the muscle remains stationary.
 - d) The insertion of the muscle is extremely strong and can withstand strains many times greater than the load lifted by the muscle.

Crossword



ACROSS

3. another name for voluntary muscle
5. standing position
7. smooth muscle
9. muscle contraction that results in movement
11. straightening of the arm
13. muscle found along the intestine
14. muscle found in the heart
15. attaches muscle to bone
16. where neurons end in muscle (two words)
17. muscle attachment that anchors muscle to bone

DOWN

1. muscle attachment to movable bone
2. contraction of muscles that does not result in movement
4. condition of readiness in muscles
6. muscles pulling against each other
8. moves bones towards each other
10. shortening of a muscle
12. type of muscle filament

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. b) |
| 2. b) | 7. b) |
| 3. b) | 8. d) |
| 4. d) | 9. d) |
| 5. d) | 10. b) |

ANSWERS TO CROSSWORD

ACROSS

3. skeletal
5. posture
7. involuntary
9. isotonic
11. extension
13. smooth
14. cardiac
15. tendon
16. end plates
17. origin

DOWN

1. insertion
2. isometric
4. tone
6. antagonistic
8. flexion
10. contraction
12. actin

Selected Readings

1. Cohen, Carolyn, "The Protein Switch of Muscle Contraction," *Scientific American* (November 1975).
2. *Family Life and Health Encyclopedia* (New York: Marshall Cavendish Corp., 1970).
3. Karpovich, Peter and Wayne Sining, *The Physiology of Muscle Activity* 7th Ed. (Philadelphia: W. B. Saunders, 1971).
4. McClintic, Robert, *Basic Anatomy and Physiology of the Human Body* 2nd Ed. (New York: John Wiley & Sons, 1980).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Muscle: Dynamics of Contraction." 21 min col., EBE
2. "Muscle: Electrical Activity of Contraction." 9 min col., EBE

FILMSTRIPS

1. "The Muscular System." Visual Education Centre, Canada

WARDS SUPER-8 FILMLOOPS

1. "Frog Skeleton Muscle Response." Arbor Scientific, Ont.
2. "Flexors and Extensors." Arbor Scientific, Ont.

Unit IV

Communication and Control of the Body

Chapter 6

The Nervous System

Chapter Focus

The amount of material available in this topic is rather overwhelming for the student, and the teacher must clarify to what depth to develop the topic.

The nervous system is a communication and control system, which forms the main link between the body and its environment. The neuron is the unit of this system and should be emphasized. Transmission of the nerve impulse and its action at the synapse is also fundamental to an understanding of the nervous system.

A general mapping of the parts of the brain and their respective functions can be absorbed by students at almost any level. The cranial nerves and the more complex neural pathways should not be attempted with slower classes.

The brain is well protected by the cranium, but any injury to the brain or the spinal cord will have drastic effects on the behaviour or co-ordination of the individual.

Students should be familiar with the reflex arc and the general principles of the autonomic nervous system.

Study of the section on drugs will depend on what coverage is given within other departments in the school. It is a topic that should be covered, but one that is not necessarily evaluated by conventional testing procedures. An open discussion, without teacher bias, is paramount.

Objectives

After studying this chapter, the student should be able to

- list the activities of the nervous system
- give the general functions of the central, peripheral, and autonomic nervous systems
- draw and label a diagram of a neuron
- explain how nerve impulses are transmitted
- describe the working of a synapse
- label a diagram of the brain
- give the functions of the parts of the brain
- identify the major cranial nerves
- describe how the brain and spinal cord are protected
- draw, label, and explain the function of a reflex arc
- differentiate between the functions of the sympathetic and parasympathetic systems
- be familiar with the action of drugs on the nervous system
- differentiate between the various categories of drugs

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Nervous System	*	
Parts of the Nervous System	*	
The Neuron	*	
Transmission of the Nerve Impulse	*	
The Brain and Its Parts	*	
Parts of the Brain	*	
The Motor Activities of the Cerebral Cortex	*	
Speech, Appreciation, and Memory		*
The Inner White Matter of the Brain		*
Cranial Nerves		*
Protection of the Brain	*	
The Spinal Cord	*	
The Reflex Arc	*	
Injury to the Spinal Cord		*
The Autonomic Nervous System	*	
Chemicals and the Nervous System		optional

Teaching Suggestions

If provincial or school board regulations permit it, live frogs may be used to study the effects of acetylcholine and adrenalin (1:10 000 dilution) on the heart. (See "Pithing a Frog", page 86.) Acetylcholine may be added to a small piece of the intestine also. Acetylcholine slows down heart action but speeds up the rate of muscle contraction in the small intestine (peristalsis). This provides the student with a working example of the parasympathetic system.

The gastrocnemius muscle and sciatic nerve could be used to show the action of nerve stimuli on muscle contraction. (See "Nerve-Muscle Preparation", page 86.) The nerve could be stimulated with electrodes attached to a 1.5 V battery. The muscle-nerve preparation should be kept moist in Ringer's solution. Two excellent 16 mm films are recommended (see "Visual Aids").

Models or a preserved brain of a sheep or similar mammal should be available for study of the major divisions of the brain.

In the case study of "Epilepsy" on page 151 of the text, try to develop in students a sympathetic understanding of the difficulties of others. Some very positive results often occur when this subject is presented by a handicapped person who has learned to cope with such difficulties.

The facts on "Drugs and Alcohol" must be objectively presented. If resource persons are used, they should be carefully checked for their views, attitudes, and expertise in this area.

For updated information, write to
 The Addiction Research Foundation
 33 Russell Street
 Toronto, (Ontario)
 M5S 2S1

This foundation supplies, free of charge, an excellent group of factsheets on the following topics:

Cannabis, January 1981
Caffeine, January 1981
Cocaine
Hallucinogens
Inhalants
L.S.D.
Opiates
P.C.P.
Tobacco
Tranquilizers
Alcohol
Amphetamines
Barbituates

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 170)

- | | |
|-------------------------|-----------------------------|
| 1. synapse | 6. Automatic Nervous System |
| 2. axon | 7. cerebellum |
| 3. meninges | 8. cerebrum |
| 4. sympathetic division | 9. Central Nervous System |
| 5. sensory neuron | 10. hypothalamus |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 170)

1. See Figure 6.2, page 137, in the text.
The cell body receives impulses from the dendrites. The functions of the nucleus and organelles in the cell body are the same as in any cell.
Axons are extensions of the cell body and carry impulses away from the cell body.
2. Cerebrum - intellect, visual, auditory, speech, etc.
Cerebellum - co-ordination of motor activities
Medulla - controls heart rate and breathing
3. The brain is protected by the cranium, or skull, and the meninges which contain fluids.
4. See Figure 6.15, page 156, in the text.
5.

a) cerebrum	e) medulla
b) cerebrum	f) cerebrum
c) cerebellum	g) cerebrum
d) medulla	h) cerebrum
6.

a) junction between two neurons
b) protective membranes around the central nervous system
c) a branching set of processes that carry impulses to the cell body

- d) The reaction time is the period of time from the point of stimulus to the end of the reaction. For example, it is the time it takes for a knee jerk; the hammer stimulates the nerve below the knee cap, the impulse goes to the spinal cord and back to the muscle of the thigh, and the foreleg moves.
7. White matter consists of nerve cells with myelinated fibres, whereas gray matter has nerve cell bodies and synapses.
 8. In this situation, pupils dilate, skin vessels constrict, heart rate increases, blood pressure is elevated, and sugars are oxidized in muscles to produce more energy. Muscles react more forcibly.
 9. "Feeling nervous" results from the conscious sensations of emotions. Excitement involves both the sympathetic and parasympathetic systems, causing increased wakefulness, blood pressure elevation, etc. Fear and anxiety produce similar effects.
 10. Acetylcholine is released from vesicles as an impulse passes from an axon. The action potential moves to the dendrite of the second nerve at the synapse. Acetylcholine is destroyed by the enzyme cholinesterase immediately after its release so that its effect is of a very short duration.
 11. Student research.
 12. Stimulants, depressants, and hallucinogens.

Text Activities

ACTIVITY 1: A COMPARISON OF REACTION TIMES (TEXT, PAGE 171)

MATERIALS FOR ACTIVITIES 1-8

30-cm ruler, rubber reflex hammer, cotton thread, feather, flashlight or other source of light, Q-tip

ACTIVITY OBJECTIVES

1. to test ability to react to a simple motor activity
2. to indicate which hand is better co-ordinated to perform a task

PREPARATION TIPS

In this activity the student will test his or her reaction times. Suggest to students that they trace the pathways involved in accomplishing this activity. The impulse is first received by the eye and sent to the visual cortex and motor areas. Giving the signal "ready" sets up anticipation, so students might also try this activity without giving the preparatory signal. The dominant hand responds more quickly in reactions of this kind.

ACTIVITY 2: HUMAN REFLEXES (TEXT, PAGE 172)

ACTIVITY OBJECTIVES

1. to understand the pathways of a simple reflex system
2. to draw and label a reflex arc
3. to differentiate between sensory and motor responses
4. to illustrate the protective reflexes of the body

PREPARATION TIPS

By hitting the patella tendon with a rubber reflex hammer, the quadriceps femoris muscles contract to lift the leg and extend the knee. Any kind of muscle activity is due to action potentials set up by nerves. Voluntary muscles depolarize upon contraction. As muscles contract, more blood is sent to them for energy consumption. Warming up or clenching the fist will allow muscles to prepare for activity.

Stress and the adrenal "flight or fright" hormone will allow more blood to pass to muscles, and less to the skin. Adrenalin is important in this respect. See pages 403 and 405 of the text. Figure 6.15, page 156, in the text illustrates a simple reflex action. The level of the spinal cord involved is about the 2nd and 3rd lumbar.

ACTIVITY 3: THE ACHILLES REFLEX (TEXT, PAGE 173)

ACTIVITY OBJECTIVES

1. to demonstrate another kind of simple reflex action

PREPARATION TIPS

Tapping the Achilles tendon makes the gastrocnemius muscle contract. This is the "ankle jerk".

ACTIVITY 4: THE PUPILLARY (TEXT, PAGE 173)

ACTIVITY OBJECTIVES

1. to demonstrate the pupillary reflex of the eye
2. to deduce that the ciliary muscles are controlled by the autonomic nervous system

PREPARATION TIPS

The lens is suspended by ligaments which attach to the ciliary muscles. In darkness or in viewing distant objects, the ciliary muscles relax and pull the ligaments, causing the lens to flatten and the pupils to dilate. The opposite is true when the eye focusses on objects that are near and in light.

ACTIVITY 5: THE ACCOMMODATION REFLEX (TEXT, PAGE 173)**ACTIVITY OBJECTIVES**

1. to demonstrate that the pupil of the eye reacts as light intensity varies and when near and distant objects are observed
2. to examine the structure of the iris and its action when focussing on near and distant objects

PREPARATION TIPS

(See "Preparation Tips" for Activity 4.)

ACTIVITY 6: THE UVULA REFLEX (TEXT, PAGE 174)**ACTIVITY OBJECTIVES**

1. to demonstrate the action of the uvula when food is in the pharynx
2. to demonstrate the importance of the voluntary response of swallowing

PREPARATION TIPS

In the action of swallowing, the uvula moves backward and will partially close the opening that leads from the nasal passageway into the pharynx.

ACTIVITY 7: THE SNEEZING REFLEX (TEXT, PAGE 174)**ACTIVITY OBJECTIVES**

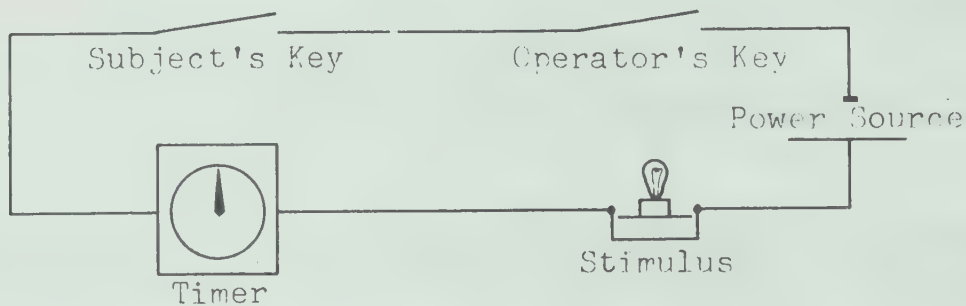
1. to trace the pathway of a sneeze reflex
2. to show the effect of a stimulus on receptors in the nostril

PREPARATION TIPS

When the nasal passageways are irritated, the trigeminal or fifth cranial nerve sends impulses to the medulla where the reflex is integrated. Air block occurs at the soft palate and pressure increases in the lungs. The uvula pushes downward and air passes through the nose. The nasal passageways are cleared of foreign matter. Students could infect the entire class in a sneeze, so precautions should be taken to safeguard against this.

ACTIVITY 6.A: DETERMINATION OF THE REACTION TIME FOR SEVERAL DIFFERENT TYPES OF STIMULI AND THE NERVE PATHWAYS INVOLVED

The reaction-time apparatus consists of two keys or pressure switches, one operated by the subject and the other by the operator. A source of light and sound to act as the stimulus, a source of power, and an electric timer capable of measuring to 1/100 s are also required.



METHOD

1. The subject will close the key and keep it closed until the stimulus is received, at which time he or she will release the key to break the circuit and stop the timer.
2. The operator will close his or her key to close the circuit, start the timer, and give the stimulus. The operator must continue to keep the key closed until the subject reacts.

This experiment is probably best performed as a demonstration using several subjects from both sexes and tabulating the results on the chalkboard.

REACTION TO SIGHT

Test the subject's response to the light stimulus. Make several trials and average the results. Record the results in a suitable table and later compare these with the results obtained by other students.

REACTION TO SOUND

Test the subject's response to a sound stimulus. Often the click of the operator's key is sufficient sound.

REACTION TO TOUCH

Blindfold the subject. Place his or her hand on the key. The operator will then tap the subject's arm, at the same time closing the circuit. Record

continued . . .

the results and comment on the kinds of experimental errors that arise in this trial. Can you design an improved system to eliminate these errors?

REACTION TO WORD ASSOCIATIONS

When the operator presses the starting key, he or she will simultaneously give a stimulus word such as "black". The subject will press his or her key and simultaneously give a word that he or she associates with the stimulus word, such as "white". Make up a list of word pairs before you start, but do not let your partner know these words in advance. You can expect that there will be a wide variation in time in this trial, depending on the word pairs used.

Note: You might try to make up a piece of equipment with three coloured switches and three coloured stimulus lamps. In this case the subject must not only respond but also make a decision about which switch he or she must press.

Comment on the kinds of experimental errors that occur in these experiments. Compare results for each type of trial and average the results. You may be surprised at how close some of the results are.

Account for the variation in time between the early trials and those requiring a decision.

What nerve pathways are involved in these experiments? Does the reaction time improve with practice?

ACTIVITY OBJECTIVES

1. to demonstrate that there is a time lapse between stimulus and response
2. to show that some responses occur faster than others
3. to understand that responses that require a choice or a decision take much longer to achieve

PREPARATION TIPS

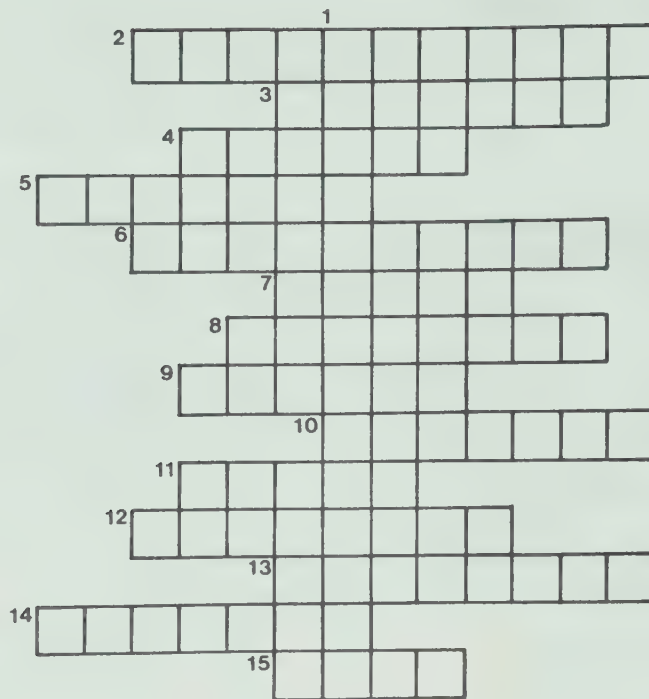
There is a surprising correlation among students in each particular task - usually only a few hundredths of a second separate the results. The room must be quiet and free from distractions to allow subjects to concentrate on responding.

The pairs of words test often causes some mix-ups with students. They verbally respond, forgetting to push the key, or push the key, forgetting to say the word. However, a general pattern still emerges for comparison with the simpler non-choice tasks.

Self-test: Select the best answer

1. The part of the brain associated with learning is the
 - a) cerebellum
 - b) cerebrum
 - c) pons
 - d) medulla
2. The part of the central nervous system that deals with reflex actions is the
 - a) cerebrum
 - b) pons
 - c) spinal cord
 - d) cerebellum
3. Smooth muscles are under the control of
 - a) the central nervous system
 - b) the autonomic nervous system
 - c) the peripheral nervous system
 - d) no system - they work independently without special control
4. Which of the following is not a part of a neuron?
 - a) axon
 - b) dendrite
 - c) synapse
 - d) cell body
5. Which of the following is not a function of the autonomic nervous system?
 - a) respiration
 - b) regulating blood pressure
 - c) controlling posture
 - d) maintaining balance
6. If the spinal cord is cut it will
 - a) regenerate
 - b) not regenerate
 - c) cause paralysis of the body below the cut
 - d) Both b) and c) are correct.
7. A reflex arc represents
 - a) a learned response
 - b) an unlearned response
 - c) a conditioned response
 - d) Either a) or b).
8. The sympathetic division of the autonomic nervous system
 - a) prepares the body for emergencies
 - b) conserves body resources and preserves homeostasis
 - c) prepares the body for long-term stress
 - d) is not involved with stress of any kind
9. The size of a reaction depends upon the
 - a) number of impulses received by the brain
 - b) size of the impulses received
 - c) number and size of the impulses received
 - d) distance of the stimulation from the reaction muscles
10. Which of the following does not affect reaction time?
 - a) alcohol
 - b) fatigue
 - c) the age of the person involved
 - d) the sex of the person involved

Crossword



DOWN

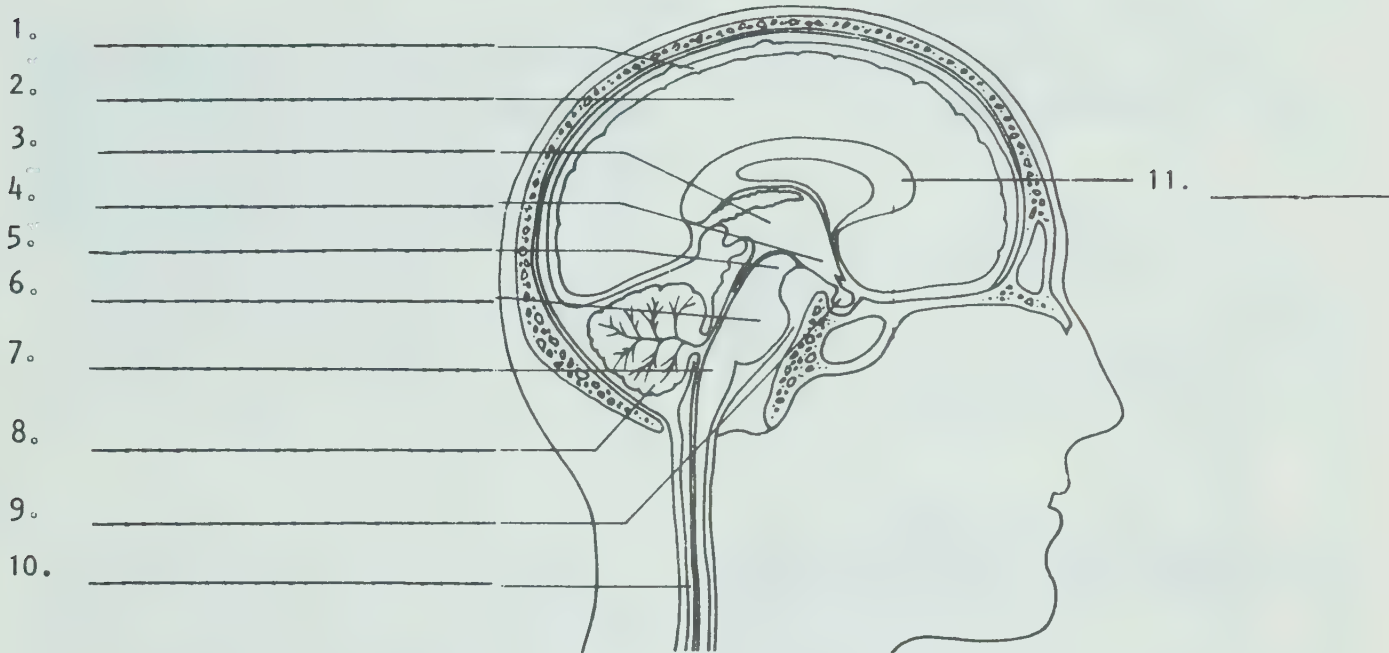
1. the outer part of the largest portion of the brain, responsible for sensory and motor activities throughout the body (2 words)

ACROSS

2. the middle neuron of a three-part reflex arc
3. the neuron that carries the impulse to the Central Nervous System
4. single nerve cell
5. the "message" that travels along a nerve
6. part of the brain responsible for the co-ordination of muscles
7. major part of the C.N.S.
8. a response to a stimulus
9. act that happens without conscious thought
10. an important nervous system in the body
11. neuron that carries an impulse to the muscles
12. the part of a neuron that receives an impulse
13. recognized by specialized nerve cells and produces a response
14. "gap" between two neurons
15. part of a neuron that carries an impulse away from the cell body

The Human Brain

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. d) |
| 2. c) | 7. b) |
| 3. b) | 8. a) |
| 4. c) | 9. a) |
| 5. c) | 10. d) |

ANSWERS TO CROSSWORD

DOWN

1. cerebral cortex

ACROSS

2. association
3. sensory
4. neuron
5. impulse
6. cerebellum
7. brain
8. reaction
9. reflex
10. central
11. motor
12. dendrite
13. stimulus
14. synapse
15. axon

LABEL ANSWERS TO "THE HUMAN BRAIN"
(Taken from Figure 6.7, text page 143)

- | | |
|--------------------|----------------------|
| 1. cerebral cortex | 7. medulla oblongata |
| 2. cerebrum | 8. cerebellum |
| 3. thalamus | 9. pituitary gland |
| 4. hypothalamus | 10. spinal cord |
| 5. midbrain | 11. corpus callosum |
| 6. pons | |

Additional Resource Material

More information on the use and effects of alcohol can be obtained by writing to

The Addiction Research Foundation
33 Russell Street
Toronto, (Ontario)
M5S 2S1

WHAT IS THE LAW?

Section 234 of the *Criminal Code* states that it is an offence to drive while impaired by alcohol or a drug. Thus a driver may be deemed to be impaired at a blood alcohol concentration of less than 80 mg%.

Section 234.1 of the Code states that a peace officer may demand a roadside screening test of a driver where he has reason to suspect the presence of alcohol in the driver's body. It is an offence to refuse to take this test.

Section 235 of the Code states that breath tests for blood alcohol concentration are compulsory on demand. It is an offence to refuse to take such tests for blood alcohol concentration when a peace officer has reasonable and probable grounds to demand them.

Section 236 of the Code states that it is an offence to drive if blood alcohol concentration exceeds 80 milligrams percent (80 mg% or .08).

The penalties for each of these sections are the same.

First offence — a fine of not more than \$2,000.00 and not less than \$50.00 or imprisonment for 6 months or both.

Second offence — imprisonment for not more than 1 year and not less than 14 days.

Subsequent offences — mean imprisonment for not more than 2 years and not less than 3 months.

AND THE LOSS OF YOUR DRIVER'S LICENCE

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ALCOHOL WILL AFFECT YOUR DRIVING ABILITY

The concentration of alcohol in a person's blood is a guide to how much your driving may be impaired.

To estimate the concentration of alcohol in the blood, follow these directions:

1. COUNT YOUR DRINKS (1 drink equals 43 mL (1½ oz.) of spirits or 85 mL (3 oz.) of wine or 341 mL (12 oz.) of beer).
2. Refer to the BLOOD ALCOHOL CHART on the opposite page. Under the number of drinks and opposite your body weight, find the concentration of blood alcohol listed.
3. Subtract from this number the concentration of alcohol burned up in your body during the time elapsed since your first drink.

Hours since first drink	1	2	3	4	5	6
Subtract from blood alcohol	15	30	45	60	75	90 mg%

Example —

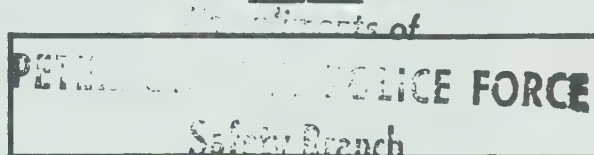
68 kg (150 lbs.) man, 4 drinks in 3 hours = 116 minus 45 = 71 mg%

68 kg (150 lbs.) man, 6 drinks in 4 hours = 174 minus 60 = 114 mg%

See back cover for the LAW IN CANADA

Canada Safety Council BLOOD-ALCOHOL CHART

For Use BEFORE Drinking

**BLOOD-ALCOHOL CHART**

Showing estimated mg% of alcohol in the blood by number of drinks in relation to body weight. (1 drink equalling 43 mL (1½ oz.) of rum, rye, scotch, brandy, gin, vodka, etc; one 341 mL (12 oz.) bottle of normal strength beer, or 85 mL (3 oz.) of fortified wine or 142 mL (5 oz.) of table wine.)

Count 1 drink of over-proof rum as 2 drinks.

DRINKS	1	2	3	4	5	6	7	8	9	10
45 kg (100 lbs.)	43	87	130	174	217	261	304	348	391	435
57 kg (125 lbs.)	34	69	103	139	173	209	242	278	312	346
68 kg (150 lbs.)	29	58	87	116	145	174	203	232	261	290
79 kg (175 lbs.)	25	50	75	100	125	150	175	200	225	250
90 kg (200 lbs.)	22	43	65	87	108	130	152	174	195	217
102 kg (225 lbs.)	19	39	58	78	97	117	136	156	175	195
114 kg (250 lbs.)	17	35	52	70	87	105	122	139	156	173

Driver impairment is reached before there are 80 milligrams of alcohol in 100 millilitres of blood (the method of expressing the concentration may also be shown as 80 mg% and/or .08 — point zero eight).

For Safety — DON'T DRINK and DRIVE

(Courtesy Canada Safety Council)

Selected Readings

1. Axelrod, Julius, "Neuro-Transmitters," *Scientific American* (June 1974).
2. Bailey, Ron *et al.*, *The Role of the Brain* (New York: Time-Life Books, 1975).
3. Bullock, T.H., *Introduction to the Nervous System* (San Francisco: Freeman and Co., 1977).
4. Greenberg, Joel, ed., "Schizophrenic and Brain Inbalance," *Science News* (April 29, 1978).
5. Hart, Leslie A., *How the Brain Works: A New Understanding of Human Learning, Motivation, and Thinking* (New York: Basic Books, 1975).
6. Lester, H.A., "The Response to Acetylcholine," *Scientific American* (February 1977).
7. Nathanson, J.A. and P. Greengard, "Second Messengers in the Brain," *Scientific American* (August 1977).
8. Pappenheimer, John R., "The Sleep Factor," *Scientific American* (August 1976).
9. Pickett, J.B., "Nerve Terminals Are as Different as the Muscles They Innervate," *Science* (November 21, 1980).
10. Routtenberg, Aryeh, "The Reward System of the Brain," *Scientific American* (November 1978).
11. Siegel, Ronald S., "Hallucinations," *Scientific American* (October 1977).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Nerve Impulse." 22 min col., EBE
2. "The Hidden Universe: The Brain." 48 min col., McGraw-Hill
3. "Sleep." 27 min, NFB
4. "Acupuncture." From "The Nature of Things". 26 min col., NFB
5. "Drugs and the Nervous System." 18 min col., Churchill Films
6. "Alcohol: Pink Elephant." 15 min col., Encyclopedia Britannica Films
7. "Fetal Alcohol Syndrome." 15 min col., EBE

FILMSTRIPS

1. "The Nervous System." Visual Education Centre, Canada Ltd.

Chapter 7

The Eye and Vision

Chapter Focus

Much of the value in this chapter results from the activities that are performed by the students to test their own vision. Students who do not wear glasses but have poor vision will soon discover this. A surprising number of students cannot pass the vision criteria set by the Ministry of Transport, but hold valid drivers' licences. Teachers can encourage students to face these problems and make adjustments, within the operation of the classroom.

The structure and function of the eye and its parts is very straightforward and most students find no difficulty with this topic. The personal application of the experiments in the chapter is very worthwhile.

Objectives

After studying this chapter, the student should be able to

- describe the structures and functions of the parts of the eye
- draw and label a diagram of the eye
- list and explain the action of the extrinsic muscles of the eye
- describe how the eye is protected
- identify the location of the lacrimal glands and give the path and action of their secretions
- explain the general workings of the retina and the action of the rods and cones
- describe the reflex actions of the eye
- state the value of binocular vision
- list the types of vision defects, give the reasons for these defects, and explain what treatment can help to solve these vision problems

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
Vision and the Structure of the Eye	*	
The Cavities That Contain the Eye	*	
Muscles of the Eye	*	
Protection of the Eye	*	
The Internal Structures of the Eye	*	
The Reflexes of the Eye		*
Binocular Vision		*
Vision Defects	*	

Teaching Suggestions

A few simple physics demonstrations that illustrate the basic principles of light are helpful and interesting to students. A ray-box, with convex and concave lenses, demonstrates the principles of refraction. Even in the senior classes, some students still believe we see "out" of our eyes. It is necessary to explain how light is reflected off an object to the eye and light rays enter the eye to stimulate the retina.

A model of the eye and the sheep's eye for dissection provides an understanding of the anatomy of the eye. The dogfish shark's head may be used for a dissection to show the various muscles that move the eye. The Time-Life Science book, *Light and Vision*, provides good drawings and illustrations of the eye. Nilsson's *Behold Man - A Photographic Journey inside the Human Body* has many excellent photographs of eye structures. The 16 mm film "Eyes and Seeing" (see "Visual Aids") is highly recommended. The physics laboratory should be able to supply convex, concave, and double concave lenses which may be used to show how light behaves and how short and far-sightedness can be corrected. Finally, there is a large selection of material on "Vision" in the Carolina Biological catalogue.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 189)

- | | |
|----------------|----------------------|
| 1. iris | 6. fovea |
| 2. retina | 7. extrinsic muscles |
| 3. cones | 8. conjunctiva |
| 4. lens | 9. cornea |
| 5. astigmatism | 10. sclera |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 190)

1. Eyebrows, eyelids, eyelashes, blinking reflex, bones of the skull
2. Superior rectus - turns eye upward
 Inferior rectus - turns eye downward
 Medial rectus - turns eye inward
 Lateral rectus - turns eye outward
 Superior and inferior oblique - rotate the eye
3. Sclera - point of attachment of extrinsic muscles, helps maintain shape of eye
 Choroid - middle layer, contains blood vessels, supplies nourishment to the eye
 Retina - consists of the rods, cones, and nerves
4. Student self-test. See Figure 7.3, page 180, in the text.
5. Approximately 70 ligaments attach radially around the lens, pulling the

lens toward the ciliary body. Ciliary bodies have two sets of smooth muscles, the radial and circular fibres. Radial fibres contract and pupils dilate; contraction of circular fibres cause constriction of the pupils.

6. Two eyes are necessary for distance perception. The position of the object becomes easier to determine with two eyes. See Activity 7.D, page 121.
7. There are no active rods and cones in this area. This area of the retina is where all optic nerves converge and leave the eye.
8. The optic nerve or visual centres of the brain could be damaged.
9. On viewing the nearby object, the lens of the eye becomes more convex and the pupil constricts as a result of parasympathetic stimulation due to increased amount of light. Ligaments relax and cause less tension on the lens. On viewing the distant object, the lens is flattened by more tension of the ligaments. Radial fibres under sympathetic control cause dilation of the pupils.
10. Short-sightedness, or myopia, results when light rays are focused in front of the retina. A concave lens will correct this error.

Text Activities

ACTIVITY 1: SNELLEN EYE CHART: VISUAL ACUITY (TEXT, PAGE 191)

MATERIALS

Snellen Eye Chart

ACTIVITY OBJECTIVES

1. to illustrate a standard comparative eye test
2. to provide the students with an opportunity to test their own vision
3. to allow students who wear glasses or contact lenses to compare their vision with and without lenses

PREPARATION TIPS

The size of letters used in the Snellen eye chart has been selected specifically for testing from a standard distance of 6 m. A person with 6/6 vision has normal visual acuity. The numerator refers to the standard distance, while the denominator indicates what the student sees when compared with a normal vision (6/6) individual. For example, 6/12 means that the person can read the line marked 12 at a distance of 6 m and has poorer vision than one who has a 6/6 vision or could read the line marked 6 from 6 m. For driving a car without glasses, the minimum acceptable standard for visual acuity is 6/12. For commercial vehicles the acceptable standard is about 6/9. The system of using

20/20 vision is still in common use by many practitioners, and teachers should refer to this during discussion.

When students close one eye, remind them not to press the eyeball with their fingers or hand; this distorts the eyeball temporarily. Ask them to use a card to shield the eye.

ACTIVITY 2: NEAR POINT ACCOMMODATION (TEXT, PAGE 191)

MATERIALS

Metre stick and pencil

ACTIVITY OBJECTIVES

1. to demonstrate the closest point at which an object can be sharply distinguished
2. to illustrate the accommodation that must be made by the lens in order to focus on distant and close objects
3. to show how age affects the flexibility of the lens

PREPARATION TIPS

The lens is a flexible elastic tissue that can assume various convex shapes. The lens is suspended by ligaments that are attached to the ciliary body or muscles that insert on the choroid. When the ciliary muscles contract, the anterior of the choroid layer is pulled forward, causing less tension on the ligaments. The lens becomes more convex. An older person's lens becomes less flexible so that the near point accommodation diminishes as shown on page 192 of the text. When the ciliary muscles relax, they tend to pull back the ligaments, and the lens will tend to flatten. Accommodation generally occurs when objects less than 6 m are being viewed. For each eye, there is a specific distance within which the eye cannot adjust; the lens has already adapted to its maximum curvature. The point at which vision becomes blurred is known as the "near point".

ACTIVITY 3: DISCOVERY OF THE BLIND SPOT (TEXT, PAGE 192)

ACTIVITY OBJECTIVES

1. to demonstrate that there are no rods or cones on a small part of the retina

PREPARATION TIPS

Since we have binocular vision, we are unaware of the existence of a blind spot on the retina. There are no rods or cones on this piece of tissue which is occupied by the optic nerve, which leaves the eye to carry impulses to the brain. If students have difficulty finding the blind spot, check that they are holding their heads and charts in a line parallel to the floor.

ACTIVITY 4: COLOUR-BLINDNESS (TEXT, PAGE 193)

MATERIALS

Ishara or Ichikawa Test booklet, any Standard Pseudoisochromatic Plates

ACTIVITY OBJECTIVES

1. to determine whether an individual has normal sight or is colour-blind
2. to obtain the percentage of colour-blind individuals (if any) in a small population
3. to provide data for the genetic determination of colour-blindness

PREPARATION TIPS

There appears to be three kinds of cones. The absorption maxima for human cones are at 445 nm (nanometres) for blue, 535 nm for green, and 570 nm for red. However, each of these wavelengths stimulates more than one type of cone. If red cones are lacking, wavelengths of red light will stimulate the green cones. Thus, the result will be a red-green colour-blindness. The test booklet directions should be studied prior to testing students. Reference to the score guide in the back of the test booklet and a comparison with the student's recorded number observations will indicate whether the student's vision is normal or the student is red-green deficient or totally colour-blind.

Additional Activities

ACTIVITY 7.A: THE RANGE OF PERIPHERAL VISION

The position of the eyes in the head varies from one animal to another. Some are at the side of the head; others are at the front. In humans the range of vision is quite limited for anything approaching from behind.

IN THIS EXPERIMENT YOU WILL DETERMINE YOUR RANGE OF VISION AND HOW THIS RANGE IS AFFECTED BY LIGHT INTENSITY AND COLOUR.

MATERIALS

hand disc or homemade perimeter (see illustration), eye patch, black wand (Carolina Biological catalogue, 69-4630)

METHOD 1

1. Hold the device horizontally and using your right eye only, line up the two sights. Keep your eye fixed along this sight line continuously, but be aware of what is taking place out of the corner of your eye, without taking your eye off the distant sight. It is most important to keep your head square to the board. Your partner should constantly check on this.
2. While you are holding the board, your partner will gradually move the pointer from the centre to the side. At the point that you can no longer see it, tell your partner, who will then record the angle. Now start with the pointer beyond your range of peripheral vision, and gradually bring it into view. Record this angle and average it with the last figure. Record this angle as "right" angle of the right eye. Make a suitable table in your notebook to record all your results.

EYE	ANGLE TO THE RIGHT	ANGLE TO THE LEFT	TOTAL RANGE
Right eye			
Left eye			

3. Now move the pointer to the left and determine the greatest angle that can be seen in this direction. Your partner should constantly check to see that your head is not being tilted to one side. Record the "left" range of vision in the table and add the two measurements together to obtain the total range of horizontal vision with the right eye. Repeat the experiment using the left eye and again record and total the angles.

continued . . .

4. Turn the frame at right angles, into a vertical position and determine what angles of vision are possible above and below the horizontal line. Record your results in a table similar to the one above.

METHOD 2

1. Tape some small coloured slips of paper to the pointer and again try the range of colour vision. Do not let your partner see the colour that you are placing on the pointer and bring the pointer into range from the side of the head. You will find that your partner can see the pointer for some time before he or she can tell the colour. (Try some darker colours like green, blue, red, and brown.) Don't let the person being tested flick his or her eyes to the side: tell your partner to keep his or her eyes on the sight line.
2. Record the range of vision for colour in bright light. Dim the lights and again try the experiment and record your results.

METHOD 3

Check on the function and location of the "fovea" before you start this experiment.

Tape a short, typed word to the pointer and move it into your partner's range of vision. You will find that only a very small angle of recognition exists for this identification.

Explain why the range for word identification is so small. What part of the eye is used? Explain the differences in the range of vision. What limits the vision to left, right, up, and down for the right eye?

Explain the differences in your ability to correctly identify colour between dim light and bright light. Why are accident witnesses notoriously inaccurate about the colour of cars after dark or in dim light?

Have a student walk slowly by you from behind. Determine at what point you first see him or her. Make sure that your head and eyes are directly to the front. Now close the eye on the side that the student is passing and again measure the distance in front of you, at the point where you first see him or her. This is a very important factor for persons who lose the sight of one eye. Find out if persons who have sight in only one eye are allowed to drive a car. Discuss the advantages and disadvantages of the position of the eyes in the human body.

continued . . .

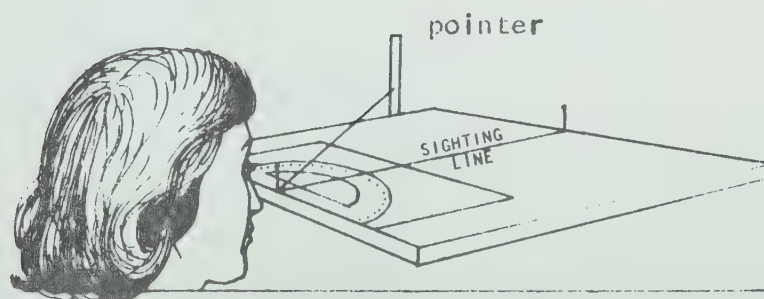
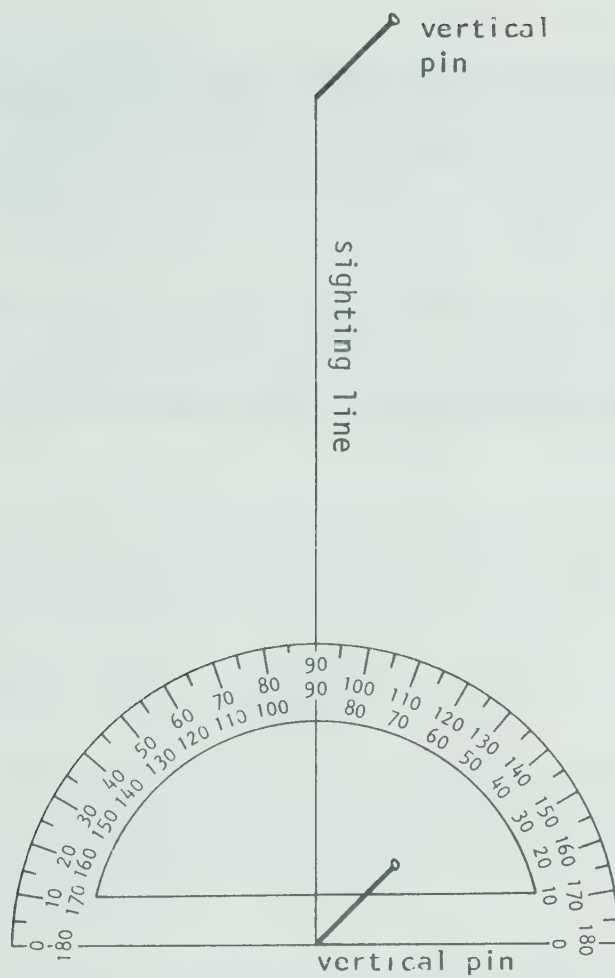


Figure: Illustration of homemade perimeter - Activity 7.A.

ACTIVITY OBJECTIVES

1. to determine the range of peripheral vision from the right and left side
2. to compare the vertical and horizontal range of vision
3. to relate the peripheral range of vision to the location of the rods and cones in the retina

PREPARATION TIPS

The hand disc perimeter can be turned in a vertical or horizontal position more easily than mounted models. The black wand has four circular white pasted papers of diameters of 1 mm, 2 mm, 3 mm, and 4 mm as targets. The perimeter can be easily constructed as suggested in the sketch.

ACTIVITY 7.B: AFTER-IMAGES

Discover the effects of after-images.

Two types of after-images can be distinguished. Positive after-images are those that appear in the same colour as the original object. Negative after-images produce the opposite colours - dark colours appear light, reds appear as greens, etc.

MATERIALS

a variety of coloured gummed shapes pasted onto a white card

METHOD

1. Look at a light bulb or a penlight for an instant, then close your eyes. Describe what you see, state both the colour and shape of the image. What type of after-image is this?
2. Repeat, but this time instead of closing your eyes stare intently at a white sheet of paper. What changes do you see?
3. Take a card on which several small shapes in the three primary colours have been glued. (Gummed shapes can be bought from toy stores or stationers.) Stare intently at the shapes for a minute or two, then quickly transfer your gaze to a sheet of white paper. Record what you see; again notice both the colour and shape.

Negative after-images are produced by the bleaching or fatiguing of certain visual pigments caused by over-long contact with light of a particular colour. Saturation of the pigment occurs and the complementary colour is seen.

ACTIVITY OBJECTIVES

1. to demonstrate that there are two kinds of after-images, positive and negative
2. to show how the three cone types interact

PREPARATION TIPS

See page 186 of the text for explanations.

ACTIVITY 7.C: ASTIGMATISM

Discover if you have any distortion of the lens or cornea caused by astigmatism.

Astigmatism is caused by some irregularity in the shape of the lens or cornea, which bends the light rays entering the eye and blurs some part of the image.

MATERIALS

Refer to Figure 7.9, page 189, in the text.

METHOD

Close one eye and examine the diagram Figure 7.9. Determine if all the radiating lines appear equally black and distinct. If all the lines appear equally sharp then you do not suffer from astigmatism. If any of the lines appear blurred or less distinct, it is probable that you have some degree of astigmatism. Check both eyes and record your observations for each eye. Make a statement in your notebook about what astigmatism is, what causes it, and explain your results.

ACTIVITY OBJECTIVES

1. to test for any irregularity of the cornea and lens of the eye
2. to understand how a corrective lens can correct this abnormality

PREPARATION TIPS

Students will have probably noticed how small irregularities in window glass, especially older panes of glass, distort an image. This can be related to irregularities in the curvature of the cornea or lens which make some lines on the diagram blurred, while the next ones remain in sharp focus.

ACTIVITY 7.D: BINOCULAR VISION

Investigate the advantages of looking with two eyes.

MATERIALS

test tube, test tube rack, pencil, needle, thread

METHOD I

Place the test tube upright in the rack, just within reach of your hand. Using both eyes, attempt to insert the pencil into the test tube. Draw the hand back close to the body each time and make one direct attempt. Do not slow down or hesitate. Record how many successful attempts you achieved out of six trials.

Now close one eye and try again, without any hesitation, to place the pencil in the test tube. Count the successful attempts, then repeat using the other eye.

Explain the advantage of binocular vision.

Explain how depth perception is achieved.

Sometimes swimmers make poor assessments of distance across water and have difficulty reaching some objective, because the objective appeared nearer than it actually was. Swimmers have been drowned by this error in distance perception. Explain how this misjudgment occurs.

METHOD II

Try to thread a needle, first using both eyes, then the left eye only, then the right eye only. Compare and explain the results.

ACTIVITY OBJECTIVES

1. to show the value of using two eyes instead of one
2. to demonstrate how binocular vision improves depth perception

PREPARATION TIPS

Teachers may wish to explain the principle by relating it to sighting a rifle, showing the need for alignment. However, the person sighting the rifle has no indication how far along the sightline the target will actually be. A second sightline enables an intersection to be made which aids the perception of depth.

ACTIVITY 7.E: ARE YOU RIGHT-EYED OR LEFT-EYED?**METHOD**

Take a sheet of looseleaf note paper that has holes punched in it. Place a penny on the floor. Stand over the penny and, holding the sheet of paper at waist height, sight the penny through one of the holes. Both eyes should be open at this point. Now close your left eye. Can you still see the penny? Now test if you can see it, using the left eye and with the right eye closed. In one case the penny will seem to jump away and you will not be able to see it. If you close the right eye and then cannot see the penny, you are right-eyed; if the reverse happens, you are left-eyed. Can you explain this event?

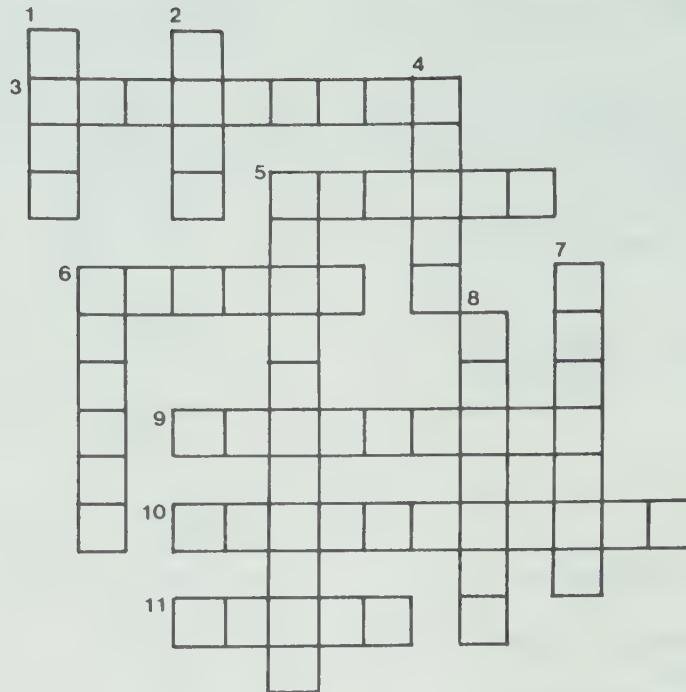
PREPARATION TIPS

This short test is of interest to students as most of them are only aware of hand or foot dominance. Sometimes special programmes are made to help young children improve the action of "lazy" muscles in the eye. This may mean covering one eye, or using a special piece of equipment in which one symbol is made to fit into, or over, another. Regular exercises can improve the external muscles of the eye just as improvements can be made in other muscles by exercise.

Self-test: Select the best answer

1. Accommodation of the lens of the eye for seeing nearby or distant objects is
 - a) a reflex action
 - b) accomplished by contraction of the muscles of the iris
 - c) a conditioned reflex
 - d) accomplished by turning the eyes inward or outward in their sockets
2. A delicate, transparent membrane in front of the eye is called the
 - a) cornea
 - b) conjunctiva
 - c) choroid layer
 - d) retina
3. The function of the ciliary body (muscle) is to
 - a) control the amount of light entering the eye
 - b) distinguish among different colours
 - c) focus the lens
 - d) distinguish dark and light objects
4. The rods of the retina make it possible to
 - a) distinguish colours
 - b) see in black and white in dim light conditions
 - c) recognize depth and judge distances
 - d) adjust to objects that are close by or at a distance
5. Astigmatism is caused by
 - a) a problem associated with the extrinsic eye muscles
 - b) an infection
 - c) an imperfection in the cornea
 - d) distortion of the retina
6. Which of the following is not a true statement?
 - a) The field of vision is limited by the bony structure of the face.
 - b) The field of colour vision is restricted by a limited number of cones.
 - c) The ability to concentrate on a single word of fine print is a function of the lens.
 - d) The ability to recognize colour is determined, in part, by the amount of light available.
7. In order to read a word of very fine print, the light rays must be focused on the
 - a) retina
 - b) cones
 - c) rods
 - d) fovea
8. Which of the following is not a true statement?
 - a) The lacrimal glands drain into the nasal cavity.
 - b) The tears contain a germicidal substance.
 - c) The tears, during emotional stress, are under voluntary control.
 - d) The tears wash away dust and lubricate the eye.
9. The amount of light entering the eye is controlled by
 - a) ciliary bodies
 - b) lens
 - c) conjunctiva
 - d) iris
10. Which of the following helps prevent night blindness?
 - a) Vitamin A
 - b) Vitamin C
 - c) Vitamin D
 - d) Vitamin E

Crossword



ACROSS

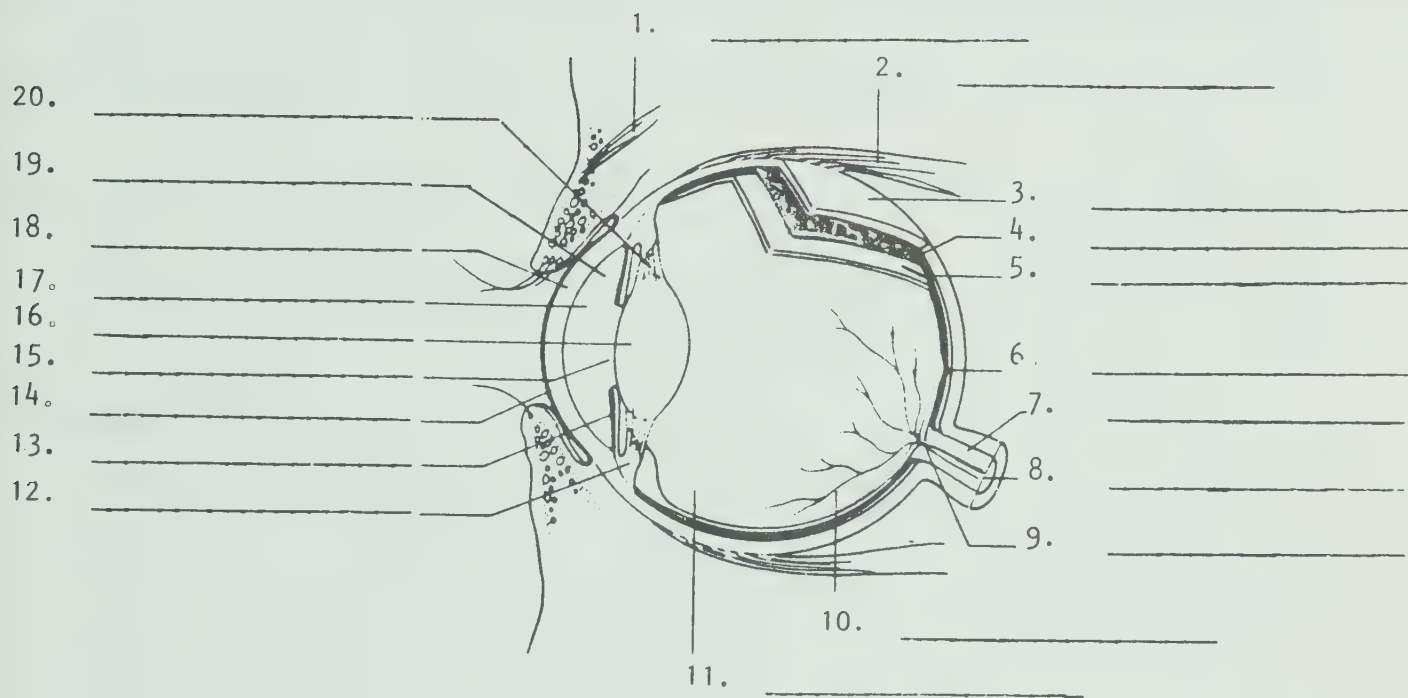
3. muscles attached to the outside of the eyeball
5. clear protective layer over the front of the eye
6. light-sensitive layer of the eye
9. vision with two eyes that gives depth and distance perception
10. defect of the cornea that distorts the image
11. point of special sensitivity on the retina

DOWN

1. enables the eye to focus light rays on the retina
2. controls the amount of light entering the eye
4. colour-sensitive cells of the retina
5. thin, transparent membrane over the front of the eye
6. name for four extrinsic muscles of the eye
7. middle layer of the eyeball
8. muscle that changes the shape of the lens

The Eye

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. c) |
| 2. a) | 7. d) |
| 3. a) | 8. c) |
| 4. b) | 9. a) |
| 5. c) | 10. a) |

ANSWERS TO CROSSWORD

ACROSS

- 3. extrinsic
- 5. cornea
- 6. retina
- 9. binocular
- 10. astigmatism
- 11. fovea

DOWN

- 1. lens
- 2. iris
- 4. cones
- 5. conjunctiva
- 6. rectus
- 7. choroid
- 8. ciliary

LABEL ANSWERS TO "THE EYE"

(Taken from Figure 7.3, text page 180)

- | | |
|---------------------|-----------------------------|
| 1. muscle of eyelid | 11. vitreous body |
| 2. rectus muscle | 12. ciliary muscle body |
| 3. sclera | 13. iris |
| 4. choroid layer | 14. conjunctiva |
| 5. retina | 15. pupil (opening in iris) |
| 6. fovea centralis | 16. lens |
| 7. optic nerve | 17. aqueous humour |
| 8. blood vessels | 18. cornea |
| 9. "blind spot" | 19. anterior chamber |
| 10. blood vessels | 20. ligaments |

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- 1. Dunn-Rankin, Peter, "The Visual Characterization of Words," *Scientific American* (January 1978).
- 2. *Family Life and Health Encyclopaedia* (New York: Marshall Cavendish Corp., 1970).

3. Gogel, W. C., "The Adjacency Principle in Visual Perception," *Scientific American* (May 1978).
4. Hammond, Ronald E., *Human Vision* (Burlington, N. Carolina: Carolina Biological Supply Co., 1980). (Pamphlet)
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8. Rushton, W. A., "Visual Pigments and Colour Blindness," *Scientific American* (March 1975).
9. Young, Richard, "Visual Cells," *Scientific American* (October 1970).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

"The Eyes and Seeing." 20 min col., EBE

FILMSTRIPS

"The Eyes and Seeing." Visual Education Centre, Canada Ltd.

WARDS SUPER-8 FILMLOOPS

- The Eye - 1. "Defects and Corrections."
2. "Function of the Retina."

Chapter 8

Other Senses – Hearing, Taste, and Smell

Chapter Focus

This chapter has a lower priority than others and teachers should adjust the time they spend on the topic accordingly. A clear understanding of how sound is transmitted is required in order to understand how sound is carried through the ear. The general structure and function of the outer and middle ear is easily conveyed to students, but the conversion of vibrations to nerve impulses in the inner ear presents difficulty.

Teachers must spend time trying to project a three-dimensional concept of the structures of the inner ear within the bony labyrinth. Students find it difficult to visualize the saccule, utricle, cochlea, and semicircular canals. This portion should be simplified for the general level students.

While taste and smell can be very interesting topics, especially with activities to support the content, time restraints dictate that they be given a lower priority.

Objectives

After studying this chapter, the student should be able to

- label a diagram of the ear
- list the structures of the ear and give the functions of each
- explain how sound travels to reach the ear and how sound is transmitted through the outer and middle ear
- explain how sound vibrations are converted to nerve impulses in the inner ear
- know some common hearing disorders and how the ear can be damaged
- describe the structures and functions of the organs of balance
- describe the structures and functions of the organs of taste
- describe the structures and functions of the organs of smell

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Ear the Hearing	*	
The Structure of the Ear	*	
How Sound Travels		*
The Middle Ear	*	
The Inner Ear	*	
Hearing Disorders		*
The Organs of Balance	*	
The Sense of Taste		*
The Sense of Smell		*

Teaching Suggestions

The inner ear is difficult for many students to visualize. Most organs of the body can be either dissected or modelled as three-dimensional objects. The inner ear, however is *inside* the bone and can never be seen in this form. Even models tend to cut away the bone and produce these structures so that they appear like any other organ that you can hold in your hand. Students have difficulty grasping that the structures are in tunnels and small cavities, surrounded by a double membrane with two layers of fluid, the endolymph and the perilymph. The teacher must take the time to explain these structures carefully with adequate use of diagrams.

If a sound level meter is available, some readings can be taken around the school and the results compared with Figure 8.6, page 201 of the text. Take readings at a school dance, for example, measuring the sound intensity at different distances from the band. Include at least one reading taken beside a player. If there are some students in the class who play in bands that use highly amplified equipment, their hearing can be tested with an audiometer. The local Health Unit usually has this piece of equipment and will either lend it, or send a staff member to the classroom, to test the hearing of students. Often the Health Unit makes an extended check of students in the public schools, and then the equipment is not used for many weeks until another check is made. If you are willing to adjust your timing, they are often willing to allow the instrument to be used by high schools.

Most physics laboratories have an audio-frequency generator, which can be used to test the range of hearing. Use the equipment with caution. Also, two matched tuning forks mounted on resonators are usually available to demonstrate sympathetic vibrations.

The film, "The Ears and Hearing", shows the mechanisms of hearing with time-lapse photography, and demonstrates the action of the bones in the middle ear. The film culminates with an operation showing the removal of the anvil and its replacement with a prosthesis. Information is available from the Workmen's Compensation Board regarding safety regulations and hazards in occupations of high noise intensities.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 206)

- | | |
|------------------------|--------------------------------|
| 1. organ of Corti | 6. ossicles |
| 2. cochlea | 7. auditory canal |
| 3. semicircular canals | 8. oval window |
| 4. endolymph | 9. oval window or round window |
| 5. eustachian tube | 10. otoliths |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 207)

1. They conduct and amplify sound vibrations to the inner ear.
2. Student self-test. (See page 196.)
3. Air carries sound waves which are collected by the pinna or auricle. These waves pass into the auditory canal and cause the eardrum to vibrate.
4. Range of human hearing is from a frequency of 16-20 000 Hz (cycles per second). Various factors will alter the hearing ability. Aging, exposure to loud noises, conduction, and nerve deafness are some factors.
5. Temporary deafness or hearing impairment occurs when the number of decibels exceeds 100-120 decibels. Continuous loud sounds may cause irreparable damage in the middle and inner ear.
6. See pages 202 and 203, Figures 8.7 to 8.9, in the text. The three semicircular canals, which are at right angles to each other, contain endolymph and hair cells. Whenever the head is shifted in any plane, movement of the endolymph activates the hair cells, which send nerve impulses to the brain.
7. This is because the fluids are still activating hair cells, even though one is stationary, producing a feeling of being disoriented.
8. Taste buds produce sensations of
Sweet taste - located on the tip
Salty taste - located on the tip and lateral margin
Sour taste - located mostly on the lateral margin
Bitter taste - located at the back of the tongue
9. Taste buds lie below the stratified squamous epithelial cells. A small opening allows dissolved substances to reach and stimulate the taste cells. Impulses from these cells pass via the lingual nerve to the cerebral cortex. Taste cells must receive sensations in solutions. Dry foods cannot penetrate into the tiny pores.
10. The sensation of smell influences the secretion of saliva. When one has a severe nasal cold, the sense of taste seems to be lost, but the person has not lost the sense of taste. When foods pass into the pharynx, the

more acute sense of smell picks up these volatile portions of food. The more acute sense of smell "tastes" our foods.

Text Activities

ACTIVITY 1: SOME INVESTIGATIONS INTO SOUND AND THE SENSE OF HEARING (TEXT, PAGE 207)

MATERIALS

tuning forks of various frequencies

ACTIVITY OBJECTIVES

1. to illustrate how the direction of a sound source is perceived
2. to show the effect of the auricle or pinna

ACTIVITY 2: AUDITORY ACUITY (TEXT, PAGE 208)

MATERIALS

Wrist watch

ACTIVITY OBJECTIVES

1. to test the sensitivity of a subject to sound vibrations
2. to compare the sensitivity of the right and left ears

PREPARATION TIPS

Some students may exhibit some conductive deafness but not necessarily nerve deafness.

ACTIVITY 3: THE CONDUCTION OF SOUND THROUGH BONE (TEXT, PAGE 208)

MATERIALS

tuning fork

ACTIVITY OBJECTIVES

1. to show the effects of sound vibrations through bony tissue or solids
2. to illustrate how some types of hearing aids by-pass the bones of the ear and conduct sound to the cochlea via the bones of the skull

PREPARATION TIPS

Students may wish to carry out the Weber test: the tip of a vibrating tuning

fork is placed on the forehead. A person with conduction deafness in one ear hears the sound of the tuning fork more loudly in the deaf ear than in the normal ear. The deaf ear is more sensitive than the normal ear to sound waves conducted into the cochlea through the bone. A person with nerve deafness in one ear hears the sound more intensely in the normal ear.

ACTIVITY 4: THE ROMBERG TEST - A TEST OF BALANCE (TEXT, PAGE 208)

MATERIALS

slide or filmstrip projector

ACTIVITY OBJECTIVES

1. to demonstrate that equilibrium is maintained more effectively when a subject's eyes are open
2. to illustrate the function of the semicircular canals

PREPARATION TIPS

Students will experience, when their eyes are closed, a greater forward-backward sway than a side-to-side one. The subject may lose static equilibrium, controlled by the utricles, which causes wavering.

ACTIVITY 5: THE SENSITIVITY OF THE TONGUE TO DIFFERENT TASTES (TEXT, PAGE 209)

MATERIALS

cotton swabs, Q-tips, 10% sucrose solution, 20% salt solution, 0.1 M acetic acid solution or white vinegar, 0.1% quinine solution, distilled water

ACTIVITY OBJECTIVES

1. to distinguish among the four primary kinds of taste
2. to determine the location of the primary taste buds
3. to understand that tasting is a chemical process that activates several taste buds when substances are in solution

PREPARATION TIPS

PREPARATION OF SOLUTIONS

10% sucrose solution: Add 37 g of sucrose to distilled water and bring to a volume of 100 mL.

20% NaCl solution: Add 12 g of sodium chloride to distilled water and bring to a volume of 100 mL.

Acetic acid solution: Use 0.1 M acetic acid. Add 5.7 mL concentrated reagent per litre solution. White vinegar is recommended.

Quinine solution: molecular weight of quinine is 324 g and of quinine sulphate is 715 g.

Add 0.715 g quinine sulphate to 100 mL distilled water. Add 0.324 g quinine to 100 mL distilled water to make 0.1% solution.

Taste sensations conform generally to those regions shown in Figure 8.11, page 205, in the text. There are many different qualities of tastes besides sweet, sour, salty, and bitter. In this exercise, different qualities of taste will be experienced by the stimulation of different combinations of primary taste buds.

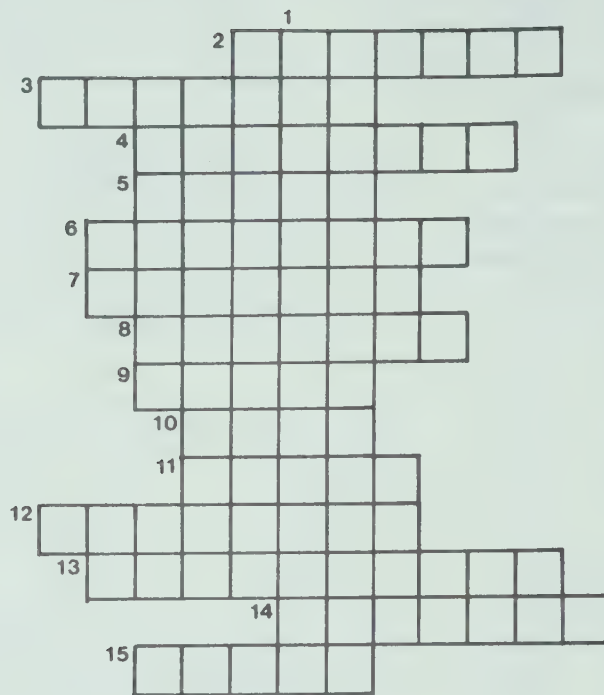
Self-test: Select the best answer

1. Which of the following is not a true statement?
The hammer, anvil, and stirrup are
 - a) found in the middle ear
 - b) transmit sound from the ear drum to the oval window
 - c) amplify the vibrations of the ear drum
 - d) transmit vibrations to the sacculle
2. The middle ear is filled with
 - a) air
 - b) perolymph
 - c) endolymph
 - d) None of these.
3. Which of the following is not a true statement?
 - a) The human ear has a normal range of approximately 16-20 000 Hz.
 - b) Children have better hearing than adults.
 - c) Sound of 200 decibels or greater is an acceptable volume for most teenagers.
 - d) Prolonged exposure to sound intensities greater than 100 decibels can produce permanent hearing loss.
4. The eustachian tube
 - a) enables fluid to drain from the middle ear
 - b) enables air pressure to be balanced on either side of the ear drum
 - c) maintains a high pressure in the middle ear
 - d) provides for changes of pressure in the inner ear
5. The organ of Corti
 - a) contains very small hair and nerve cells
 - b) is found in the middle ear
 - c) helps to change vibrations into nerve impulses
 - d) All of the above are correct.
6. The hair cells that initiate the impulses to be sent to the brain are stimulated by
 - a) the ossicles
 - b) movements of the endolymph
 - c) vibrations of the perilymph
 - d) None of these.
7. Hearing aids that use the bones of the skull to conduct sound to the inner ear are used
 - a) in cases of conduction deafness
 - b) in cases of nerve deafness
 - c) in cases of both nerve and conduction deafness
 - d) only when the ear drum has been pierced
8. The stationary position of the head or body is recognized by the stimulation of nerve cells in the
 - a) semicircular canals
 - b) utricle
 - c) cochlea
 - d) sacculle
9. A disorder involving the semicircular canals would be most likely to affect the
 - a) ability to hear high and low notes
 - b) ability to recognize the direction that sounds originate from
 - c) sensitivity to very loud sounds
 - d) sense of balance

continued . . .

10. Our ears enable us to recognize several sensations. Which of the following is not a function of the ear?
- a) awareness of the position of the body
 - b) variations in pitch
 - c) movements of the body
 - d) recognition of the body's height above the ground

Crossword



DOWN

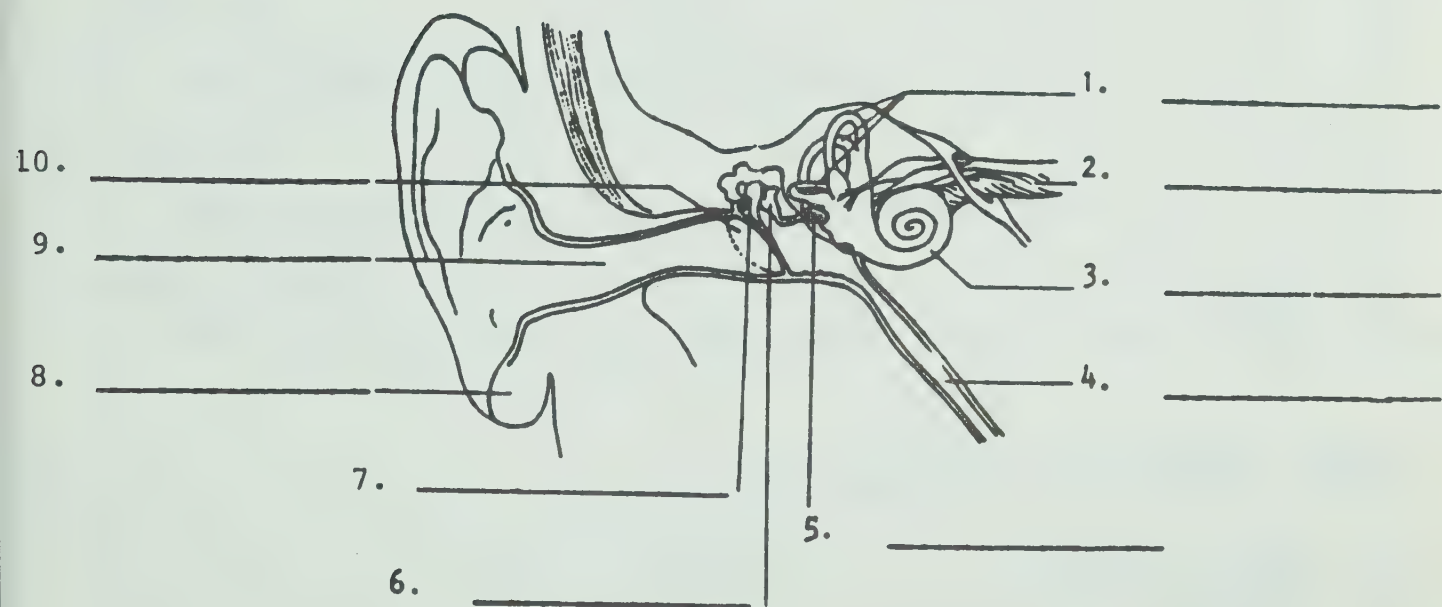
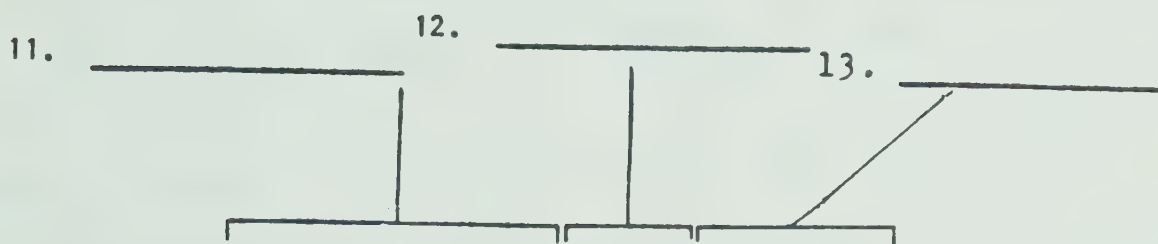
1. connects the middle ear with the pharynx (2 words)

ACROSS

2. unit that measures the relative loudness of a sound
3. small bone resting against the oval window
4. If this increases, the ear drum "bulges" and will not vibrate freely.
5. organ inside the cochlea
6. the membrane between the inner and outer ear
7. contains the otoliths and provides our sense of position
8. part of the inner ear, shaped like a snail
9. small bone in the inner ear
10. window into the inner ear
11. the outer ear, composed of cartilage
12. Sound is produced when an object does this.
13. kind of deafness when sound is not transferred to the inner ear
14. the responsibility of the semicircular canals
15. the division of the ear that contains fluid, not air

The Ear

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | | | |
|----|----|-----|----|
| 1. | d) | 6. | b) |
| 2. | a) | 7. | a) |
| 3. | c) | 8. | b) |
| 4. | b) | 9. | d) |
| 5. | c) | 10. | d) |

ANSWERS TO CROSSWORD

DOWN

1. eustachian tube

ACROSS

2. decibel
3. stirrup
4. pressure
5. Corti
6. tympanic
7. utricle
8. cochlea
9. anvil
10. oval
11. pinna
12. vibrates
13. conduction
14. balance
15. inner

LABEL ANSWERS TO "THE EAR"
(Taken from Figure 8.1, text page 196)

1. semicircular canals
2. nerves to brain
3. cochlea
4. eustachian tube
5. stirrup
6. anvil
7. pinna
8. auditory canal
9. ear drum
10. hammer
11. external ear
12. middle ear
13. inner ear

Selected Readings

1. *Family Life and Health Encyclopaedia* (New York: Marshall Cavendish Corp, 1970).
2. Oster, Gerald, "Auditory Beats in the Brain," *Scientific American* (October 1973).
3. Parker, Donald E., "The Vestibular Apparatus," *Scientific American* (November 1980).
4. Stevens, S. S. *et al*, *Sound and Hearing*. Life Science Library (New York: Time-Life Incorp., 1967).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "The Ears and Hearing." 22 min col., EBE

FILMSTRIPS

1. "The Ears and Hearing." Visual Education Centre, Canada Ltd.

SUPER-8 FILMLOOPS

1. "Function of the Inner Ear." Wards Natural Sciences - Arbor Scientific, Ont.

Unit V

How the Body Transports Substances and Defends Itself

Chapter 9

Composition of the Blood

Chapter Focus

The major function of the blood is to transport to every cell in the body its supply of oxygen and nutrients. The blood transports metabolic wastes to the kidneys and lungs for elimination and provides a messenger service to transport hormones from numerous glands to all parts of the body.

Students should have the opportunity to learn more about their blood by performing the assigned laboratory exercises. When centrifuged, whole blood reveals its components: plasma, red blood cells, and a thin layer of white blood cells above the denser red blood cells. Red blood cells carry millions of molecules of hemoglobin. Hemoglobin structure allows the uptake of O_2 , CO_2 , and CO molecules, among others. Hemoglobin also acts as a buffer to reduce the free H^+ in blood. White blood cells act principally as defence agents in the blood and tissues.

The topic can be made more relevant to students by mentioning the use of blood samples taken by doctors, the role of iron in anemia, the value of blood transfusions, and the need for blood donors.

Objectives

After studying this chapter, the student should be able to

- list the characteristics of blood
- describe the characteristics of plasma and list the substances that are contained in the plasma
- describe the structure and function of the red blood cells
- recognize the different types of white blood cells and their functions
- describe the platelets and the process of clotting
- list the blood types and draw a chart showing the antigens and antibodies present in each blood type
- draw a chart showing which blood types can be safely transfused and which blood types will cause clumping in specific cases
- explain the Rh factor and its effect on the baby of an Rh-negative mother

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
Characteristics of Blood	*	
Plasma	*	
The Function of the Red Blood Cells	*	
Anemia		*
The White Blood Cells	*	
White Blood Disorders		*
The Platelets	*	
Clotting Disorders		*
Blood Types	*	
Blood Typing	*	
The Rh Factor	*	
Blood Donors		*

Teaching Suggestions

The Blood Banks of many major hospitals will supply outdated blood that can be used to study the determination of plasma content or for hemolysis experiments. The Red Cross will supply anti-A, anti-B, and anti-Rh sera if supply houses cannot fill your order. Teachers should be aware that not all students and parents would agree to having the students pierce their fingers with a sterile lancet. Activities 2, 3, 4, and 5 can be combined into one or two groups, so that students need only prick their fingers once or twice.

The student study kits for blood typing and Rh factor, supplied by most biological supply houses, provide a simple way of carrying out these experiments, and the plasticized cards form a convenient record for students.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 222)

- | | |
|-------------|---------------------|
| 1. calcium | 6. hemoglobin |
| 2. plasma | 7. anemic |
| 3. oxygen | 8. lymphocyte |
| 4. plasma | 9. leukemia |
| 5. hormones | 10. red blood cells |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 222)

1. Student self-test. (See text, page 212.)
2. Nutrients, including vitamins, ions such as sodium, hormones, metabolic wastes, antibodies, albumins, globulins, and water (90% of plasma)

3. During the fetal stage, blood cells are produced in the yolk sac, spleen, liver, lymph nodes, and bone marrow. After birth, the red bone marrow manufactures red and white blood cells. Lymphocytes and monocytes are produced in lymphoid tissues.
4. Anemia results when there is a reduction of hemoglobin in the blood. Eating foods rich in iron and the B vitamins help a person to avoid an anemic condition.
5. Antigens of blood group A, when mixed with blood group B, will clump or agglutinate as the antigens of one type of blood react with the antibodies of the other type. (Refer to Table 9.1, page 219, in the text). Type A blood contains antigen A and type B blood contains antibody A. When an antigen and antibody are of the same symbol (i.e., both A or both B), then a reaction occurs. Type O blood has no antigens and does not stimulate a response. If the antigen and antibody have different symbols (i.e., one A and the other B), no reaction occurs.
6. Blood group O has no antigens but antibodies A and B. Type O blood can be given to any blood group. (See answer to Question 5 above.)
7. Blood group A, which contains the antigen A, can donate to blood group AB because AB blood has no antibodies to react to antigen A.
8. Step 1: prothrombin + calcium + thromboplastin → thrombin
Step 2: thrombin + fibrinogen → fibrin clot
9. An Rh-negative mother produces antibodies when some blood seeps across the placenta from an Rh-positive fetus. During the first pregnancy, the amount of antibody production is low, but the Rh-negative mother has become sensitized as a result of some antibody production in her blood stream. Thus, further exposure to the Rh-positive factor will cause greater numbers of antibodies to be produced.
10. Mononucleosis is a viral infection causing the production of high counts of lymphocytes; fever, fatigue, and sore throat are symptoms. Anemia is the result of a low hemoglobin or red blood cell count.

Text Activities

ACTIVITY 1: COAGULATION TIME (TEXT, PAGE 223)

MATERIALS

cotton, alcohol, sterile lancet, capillary tube, sweep hand clock or stop watch

ACTIVITY OBJECTIVES

1. to determine the time it takes for blood to clot
2. to demonstrate proper sterilizing techniques and the precautions to be

- taken in providing a sample of blood
3. to examine the action of blood clotting

PREPARATION TIPS

Teachers should inform their students of the nature of these experiments, and perhaps have them inform their parents before the activities are performed. All sterilization precautions must be taken. This includes having sterile lancets and sterilizing fingers. Once the skin is pierced, the finger should be gently squeezed to produce enough blood. The capillary tube should be held horizontally while it is being filled. It should not be forgotten that coagulation of blood is necessary in preventing hemorrhage.

ACTIVITY 2: PREPARING A BLOOD SMEAR (TEXT, PAGE 223)

MATERIALS

blood lancet, alcohol, cotton, 2 glass slides, microscope, Wright's stain

ACTIVITY OBJECTIVES

1. to observe a variety of blood cells
2. to make accurate drawings of blood cells
3. to note the numbers of red blood cells and to compare these with the numbers of white blood cells

PREPARATION TIPS

Less than a drop of blood is needed for this exercise. Since the Wright's stain may be left for up to 5 min, there is no need to use a coverslip. Students should prepare a *thin* smear section. The most common white blood cells are the neutrophils and lymphocytes. A prepared slide should be used for comparison. If a student happens to suffer from allergies, the blood smear will show high numbers of eosinophils. You might have students make an estimate of the proportions of white to red blood cells on their slides. This can be done by a random count in one or two high-power fields of view on a thin smear.

ACTIVITY 3: ABO BLOOD-TYPING TECHNIQUE (TEXT, PAGE 224)

MATERIALS

glass slides, Anti-A sera, Anti-B sera, toothpicks, sterile lancets, alcohol, cotton

ACTIVITY OBJECTIVES

1. to enable the student to determine his or her own blood type
2. to explain why it is important to know blood groups before a transfusion
3. to illustrate the antibody-antigen reactions
4. to determine the percentages of blood types in the class

PREPARATION TIPS

Be sure that the sera are not outdated and that they have been kept refrigerated. Before blood is transfused, both the donor and the recipient must be typed and cross-matched. Blood cells and plasma contain antigens and antibodies. A person, for instance, with type A blood contains antigen A and has type B antibodies - antibodies that will clump with type B blood (see Table 9.1, page 219, in the text). Some students may want to mix type A and B blood samples to check whether or not there is any clumping and incompatibility. When students look for clumping, the slide should be tilted and placed over a white background.

ACTIVITY 4: RH-BLOOD TYPING (TEXT, PAGE 225)

MATERIALS

glass slides, alcohol, cotton, toothpicks, lancets, Rh serum (anti-D).

ACTIVITY OBJECTIVES

1. to demonstrate proper sterilization techniques
2. to demonstrate the positive and negative reactions of the Rh factor
3. to determine the percentages of the Rh⁺ and the Rh⁻ factors

PREPARATION TIPS

The Rh factor gets its name from the Rhesus monkey, in which it was first detected. 87% of humans have this protein factor in their blood and are said to be Rh positive (Rh⁺). The remaining 13% are Rh negative (Rh⁻). Transfusion of Rh⁺ to a person with Rh⁻ may cause the Rh⁻ recipient to build up antibodies. When students view their slide preparations, slides should be tilted back and forth and kept at a temperature around 40°C. The second slide with isotonic saline solution added to blood would act as a comparison or control.

ACTIVITY 5: THE HEMOGLOBIN CONTENT OF BLOOD (TEXT, PAGE 225)

MATERIALS

Tallquist scale, lancets, alcohol, cotton

ACTIVITY OBJECTIVES

1. to recognize differences in hemoglobin levels in males and females
2. to demonstrate a simple technique by which hemoglobin levels can be assessed

PREPARATION TIPS

A low level of hemoglobin in the blood is the most common type of anemia. A lack of hemoglobin, despite the normal levels of red blood cells, will result in less oxygen uptake. Anyone who suffers from anemia may tire easily and may

be short of breath. In females, the normal percentage of hemoglobin is 80+%, and in males, it is 85+%. Borderline anemias range from 70% to 80%. People who live in high altitudes normally have higher hemoglobin counts to compensate for a lower atmospheric oxygen content. Another form of anemia is inherited (see text, page 477).

Hemoglobin is a complex protein found in all red blood cells. There are four centrally located iron atoms, which combine with O_2 , CO_2 and rapidly with CO. Hemoglobin will also tend to reduce the acidity of blood by combining with free hydrogen (H^+) ions. When reading the results of the test, be careful to compare the colour rather than the intensity of the stain.

Additional Activities

ACTIVITY 9.A: THE FORMATION OF HEMOGLOBIN CRYSTALS

METHOD

1. Allow a drop of blood to dry on a clean glass slide. Powder the blood into dust and add two drops of glacial acetic acid. Cover with a coverslip. (Salt may be used to seed the crystal if the blood is not fresh.)
2. Warm the slide gently and a few bubbles of gas will appear. Allow the slide to cool and examine it under the microscope.
3. Look for small dark crystals, rhomboid in shape. These are hemoglobin crystals. Draw the crystals in your notebook. What is the function of hemoglobin?

ACTIVITY 9.B: OBSERVE THE FORMATION OF FIBRIN STRANDS

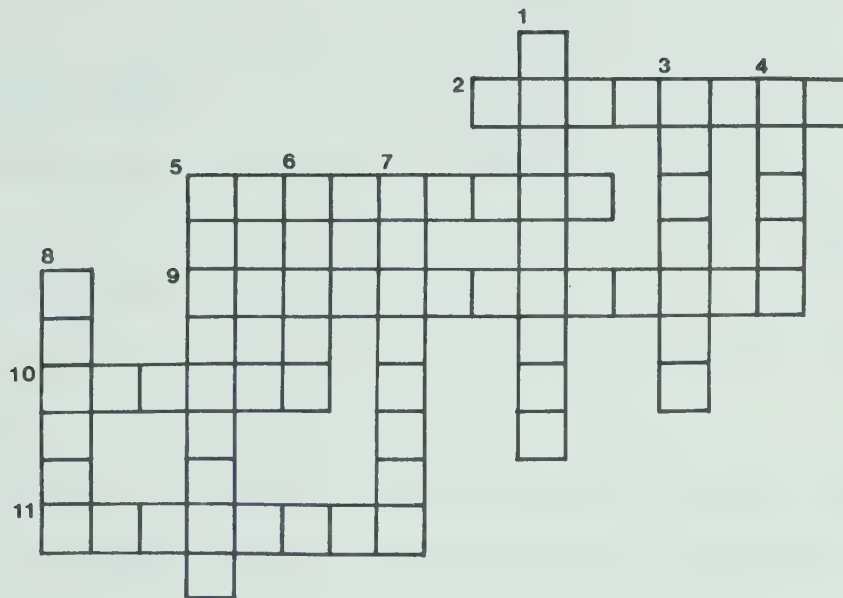
METHOD

1. Place a drop of fresh blood on a clean glass slide. Cover with a coverslip, place on the microscope, and focus carefully.
2. Touch a small drop of methyl violet solution to the edge of the coverslip and allow it to flow under and stain the blood.
3. Watch carefully for several minutes to observe the formation of fibrin strands. Touch these with a fine needle or pin to see how elastic they are. Describe the events that you see and draw the appearance of the clot.

Self-test: Select the best answer

1. The blood plasma contains
 - a) hormones
 - b) antibodies
 - c) fibrinogen
 - d) All of the above.
2. Which of the following is not a true statement?
 - a) Red blood cells contain hemoglobin.
 - b) Hemoglobin contains iron.
 - c) Hemoglobin associates strongly with oxygen.
 - d) Hemoglobin associates more strongly with oxygen than with carbon monoxide.
3. Anemia is a condition in which there are
 - a) not enough white blood cells
 - b) too many red blood cells
 - c) too many red blood cells and not enough white cells
 - d) insufficient red blood cells
4. Which of the following is a true statement?
 - a) All white blood cells have lobed nuclei.
 - b) White blood cells have no nuclei.
 - c) White blood cells have large round nuclei.
 - d) Some white blood cells have round nuclei and some have lobed nuclei.
5. Which of the following white blood cells aid in developing the body's immunity against infection?
 - a) lymphocyte
 - b) monocyte
 - c) phagocyte
 - d) neutrophils
6. Which of the following are required to promote blood clotting?
 - a) fibrinogen
 - b) calcium
 - c) prothrombin
 - d) All of the above.
7. Which of the following is not a true statement?
 - a) Hemophilia is often a sex-linked inherited trait.
 - b) Hemophilia can only occur in males.
 - c) Hemophilia occurs in both females and males.
 - d) Hemophilia involves an inability of the blood to clot normally.
8. Oxygen is carried in the blood by the
 - a) lymph
 - b) red blood cells
 - c) white cells
 - d) platelets
9. The function of the blood platelets is to
 - a) carry hemoglobin
 - b) destroy bacteria
 - c) help in blood clotting
 - d) transport carbon dioxide
10. In what circumstance is the Rh factor more likely to become a problem?
 - a) The mother is Rh+ and the father is Rh-.
 - b) The mother is Rh- and the father is Rh+.
 - c) The mother is Rh- and the baby is Rh-.
 - d) The mother is Rh- and the baby is Rh+.

Crossword



DOWN

1. a lower chamber in the heart
3. mineral required during blood clotting
4. a structure that prevents blood from flowing back into the chambers of the heart
5. the S.A. node, controlling the heart rate
6. largest artery in the body
7. "feelings" that can affect the heart rate
8. liquid part of the blood

ACROSS

2. large vessel carrying blood back to the heart (2 words)
5. small structures in the blood involved in blood clotting
9. a gas carried in the blood (two words)
10. a disorder in which blood contains an abnormally low number of red blood cells
11. vessels carrying blood away from the heart

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. d) | 6. d) |
| 2. d) | 7. b) |
| 3. d) | 8. b) |
| 4. d) | 9. c) |
| 5. a) | 10. d) |

ANSWERS TO CROSSWORD

DOWN

1. ventricle
3. calcium
4. valve
5. pacemaker
6. aorta
7. emotions
8. plasma

ACROSS

2. vena cava
5. platelets
9. carbon dioxide
10. anemia
11. arteries

Selected Readings

1. Cerami, Anthony and Charles Peterson, "Cyanate and Sickle Cell Disease," *Scientific American* (April 1975).
2. Collegiate Minicourse Program. B.S.C.S. "Animal Structure and Function," W. B. Saunders.
3. Lerner, Richard and Frank Dixon, "Human Lymphocyte," *Scientific American* (June 1973).
4. Maugh, T. H., "New Understanding of Sickle Cell Emerges," *Science* (January 16, 1981).
5. Perutz, M. F., "Hemoglobin Structure and Respiratory Transport," *Scientific American* (December 1978).
6. "Sickle Cell Anemia: Test-Tube Treatment," *Science News* (March 4, 1978).
7. "Sickle Cell Disease - Chemical Warfare," *Science News* (December 13, 1980).
8. "Wild Cells - For Secondary Schools," Canadian Cancer Society, 1980.

9. Zucker, Marjorie B., "The Functioning of Blood Platelets," *Scientific American* (June 1980).

Visual Aids

For addresses of visual aids, see Appendix B.

16 mm FILMS

1. "The Blood." 16 min col., EBE
2. "The Heart and Circulatory System." 16 min col., EBE

FILMSTRIPS

1. "Circulatory System." Visual Education Centre, Canada Ltd.
2. "Circulatory System." Wards Solo Learning Program, Arbor Scientific, Ont.
3. "Sickle Cell Anemia." Wards Solo Learning Program, Arbor Scientific, Ont.

35 mm SLIDES

1. "Human Blood Group Set." 39 slides and tape. Carolina Biological

Chapter 10

The Heart and Circulation of the Blood

Chapter Focus

The heart is one of the most vital organs in the body. Study of its structure and function offer little difficulty to most students. However, many students fail to realize that, while the heart pumps blood out to the capillary exchange sites, it has little effect on the blood's return to the heart. Teachers should take the time to stress the action of the heart valves and the valves of the veins in the body. These are the key to the return of blood to the heart.

The nervous control of the heart and blood pressure are also important aspects of the heart's action and the functioning of the circulatory system. The value of the lymphatic system, which returns fluids from the tissues to the veins, and the special role of the lymph nodes in fighting infections should also be stressed.

Objectives

After studying this chapter, the student should be able to

- list and distinguish between the different types of blood vessels
- state the differences and similarities between arteries and veins
- explain how blood is moved through arteries and how it is returned to the heart through the veins
- draw and label a diagram of the heart
- explain the action of the valves in the heart
- draw a simple diagram of the heart and show the path of blood through the heart
- explain the action of the SA and AV nodes in controlling heart rate and contraction
- be familiar with the heart beat sounds
- list the factors that affect the heart rate
- explain the importance of blood pressure and how it can be measured
- list the factors that affect blood pressure
- differentiate between the terms "systole" and "diastole"
- define "interstitial fluid"
- state the functions of the lymphatic system
- describe the location, structure, and function of the lymph nodes

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Circulation of Blood	*	
The Arteries and Other Vessels	*	
The Veins and Their Valves	*	
The Heart	*	
Heart Muscle		*
The Parts of the Heart	*	
The Heart Valves	*	
Pulmonary Circulation	*	
Nervous Control of the Heart	*	
The Heartbeat Sounds	*	
Factors Affecting Heart Rate	*	
The Volume of the Blood Pumped by the Heart		*
Regulation of the Heart Rate	*	
Blood Pressure	*	
Interstitial Fluid		*
The Lymphatic System	*	
The Lymph Nodes	*	

Teaching Suggestions

Large heart models that can be separated into two halves are the most useful for demonstrating the anatomy of the heart and circulation loops that demonstrate the action and sequence of opening and closing of heart valves (see "Visual Aids").

Relatively inexpensive pulse monitors are on the market and may be used to record emotional and physical stimuli. The transducer is clipped loosely onto the finger until a steady beat is obtained. Various stimuli may be applied and the changes registered and recognized by an audible beep or counter. The teacher may wish to induce or cause changes in the emotional state of the student - use your imagination!

The Heart Foundation will supply a number of pamphlets, free of charge, including charts of the heart circulation. The mercurial-type or the electronic sphygmomanometers are recommended for purchase, and a dual-type stethoscope should be available so that two students can listen and monitor heart rate and sounds at the same time. If funds are available, the Cardisuny 501D electronic EKG is recommended and may be purchased through Carolina Biological.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 248)

- | | |
|--------------------|-----------------------|
| 1. left ventricle | 6. capillaries |
| 2. right ventricle | 7. tricuspid valve |
| 3. systole | *8. capillaries |
| 4. The SA node | 9. interstitial fluid |
| 5. arteries | 10. spleen |

*A better answer would be "lymph vessels". (Omitted from column in text.)

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 248)

1. See Figure 10.1, page 227, in the text. Arteries carry blood away from the heart; they possess elastic tissues and contain thick smooth muscle walls. Veins carry blood toward the heart, possessing little muscles in their walls. Veins have valves and are subjected to much lower pressure than arteries. Capillaries, on the other hand, are microscopic tubes for the exchange of nutrients and wastes.
2. Student self-test (see page 232 of the text).
3. The vagus nerve, if stimulated, will slow down the rate of the heart beat. If the sympathetic nerve or cardiac nerve is stimulated, the heart rate will increase. The SA and AV nodes receive impulses from both these fibres to ensure normal atrial and ventricular contractions in a cardiac cycle. (See page 241 of the text for ECG explanation.) The SA node initiates the contraction of the atria, forcing the blood downward into the ventricles. The AV node causes the ventricles to contract from the bottom upward, forcing the blood into the aorta and pulmonary artery.
4. Exercise, temperature, emotions (such as fear, shock and excitement), CO₂ or CO concentrations, and hormones (such as acetylcholine, adrenalin and thyroxin) affect the pulse rate. During exercise, the cardiac output is increased since there is a greater demand for oxygen and nutrients for the muscles. A person who is physically fit has a stronger heart. During exercise, the heart rate of a physically fit person may not be as high as that of someone unfit, even though both hearts are delivering the same amount of blood per unit time.
5. Student exercise (see page 237 and Activity 2, page 250, of the text). The demand for blood for the muscles is less after exercise so the heart or pulse rate will be lower. The rate of recovery, i.e., the time taken for the heart rate to return to normal, is a measure of fitness: persons who exercise regularly recover their normal rate much faster than persons who do not usually exercise.
6. Veins are equipped with valves so that blood will not go backward but steadily move toward the heart. Skeletal muscles contract and pass on these waves of contraction to the veins, which keep moving blood toward the heart.

7. Some of the factors are failure of the ductus arteriosus and foramen ovale to close, poor development of valves or damage by disease or in hypertension, rheumatic fever, and blockage of the coronary vessels by a clot. Decreased flow of blood to other areas of the heart may cause angina. Blockage of the area around the aortic arch by deposits of cholesterol are another contributing factor.
8. Student self-test.
9. The lymphatic system returns filtered protein and tissue water to the blood. It produces non-granular white cells.
10. Macrophages or phagocytic cells, produced by the nodes, will engulf bacteria, cell debris, and cancer cells. These are filtered out of the blood as it passes through the lymph nodes.

Text Activities

ACTIVITY 1: DEMONSTRATE THE VALVES PRESENT IN THE VEINS OF THE ARM (TEXT, PAGE 249)

MATERIALS

rubber tubing (optional)

ACTIVITY OBJECTIVES

1. to observe the size of veins
2. to locate the presence of valves in veins
3. to explain why veins possess valves

PREPARATION TIPS

Because of the low blood pressure in veins there are valves to prevent the backflow of blood. Some veins have less than one-tenth the arterial blood pressure. Arteries are subjected to higher pressure and do not have valves. Because of the presence of valves and the continuous contractions of skeletal muscles, blood is forced through veins to the heart. This action prevents any backflow of blood. It may be of interest to note that veins contain about 60% of total blood volume.

Some students may have difficulty in showing their veins. An alternate method is to tie the upper arm firmly, keeping the upper arm down; this method allows the veins to enlarge and fill.

The important point to make in "Method 2" is that blood in the veins moves more rapidly downward than upward against gravity. Note that when both arms are kept horizontal, the size of the veins appears the same.

ACTIVITY 2: PULSE RATE (TEXT, PAGE 250)

MATERIALS

sweep hand clock or stopwatch

ACTIVITY OBJECTIVES

1. to monitor the pulse rate
2. to compare students' results
3. to check a student's physical condition
4. to demonstrate the constant variations that occur in the heart rate

PREPARATION TIPS

The pulse beat is felt during the ventricular systole of the heart. One complete heart beat corresponds to the pulse beat.

The pulse rate varies in individuals. Generally the rate is higher in females than in males. The physically fit should have a lower pulse rate at rest and a faster recovery rate after exercise. Students should consider such factors as the state of health and physical condition of an individual as they affect the pulse rate.

ACTIVITY 3: BLOOD PRESSURE (TEXT, PAGE 251)

MATERIALS

stethoscope sphygmomanometer, alcohol, absorbent cotton

ACTIVITY OBJECTIVES

1. to monitor and record blood pressure
2. to demonstrate the systolic and diastolic pressures
3. to demonstrate the factors that affect blood pressure

PREPARATION TIPS

Blood pressure is an important factor in determining the state of health of the individual. The sound of the pulse in the brachial artery is recorded as blood first passes through. The contraction of the ventricles, particularly the thick-walled left ventricle exerts a systolic pressure at an average of 120 mm Hg (16 KPa) pressure. When the sound of the pulse disappears, the average diastolic pressure is 80 mm Hg. Figure 10.15, page 242, in the text, shows the age relationship to systolic and diastolic pressures. Age, sex, size, mental attitude, activity, and health are factors that affect a person's blood pressure.

REMINDER: It would be a good idea to have students wipe off the ends of the stethoscope with alcohol before and after use. Do not allow students to over-inflate the cuff (about 150 mm Hg is adequate), or to leave the cuff inflated for too long.

ACTIVITY 4: HEART SOUNDS (TEXT, PAGE 252)**ACTIVITY OBJECTIVES**

1. to determine what produces the heart sounds
2. to have students hear their own heart beat
3. to listen to variations in heart rate
4. to list the valves that are responsible for the heart sounds

PREPARATION TIPS

The subject should be seated or lying for this exercise. The human heart sounds are important to the physician. The physician can detect problems with valves, or delayed or short atrial or ventricular contractions. Students should understand the meaning of the cardiac cycle or the general interpretation of the electrocardiogram to appreciate why and where heart sounds originate.

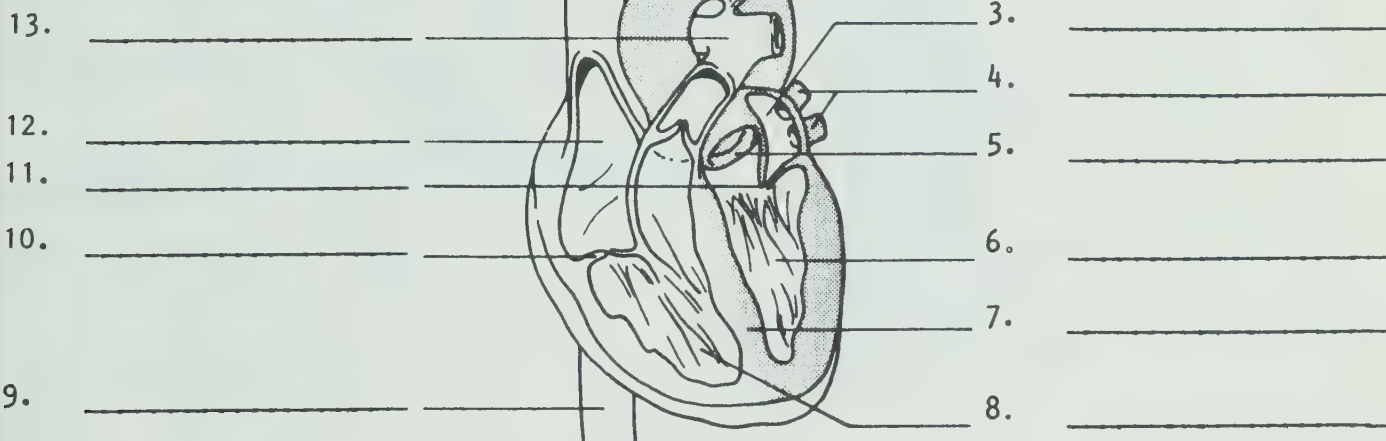
Self-test: Select the best answer

1. The pulmonary artery carries blood
 - a) to the heart from the lungs
 - b) to the lungs from the heart
 - c) to the muscles of the heart
 - d) from the heart to the rest of the body
2. The valve between the right atrium and the right ventricle is
 - a) the bicuspid valve
 - b) the tricuspid valve
 - c) a semilunar valve
 - d) a sphincter valve
3. Oxygenated blood enters the heart in the
 - a) right atrium
 - b) left atrium
 - c) right ventricle
 - d) left ventricle
4. Blood vessels with very thin walls through which nutrients and oxygen can be exchanged are
 - a) arteries
 - b) venules
 - c) capillaries
 - d) lymph vessels
5. If the amount of CO_2 in the blood increases, the heart rate will
 - a) increase
 - b) decrease
 - c) remain unchanged
 - d) vary widely
6. Valves are present in
 - a) capillaries
 - b) arteries
 - c) veins
 - d) lymph vessels
 - e) Both c) and d) are correct.
7. Which of the following factors does not affect blood pressure in the vessels?
 - a) blood type
 - b) size of the vessel
 - c) good elasticity in the vessel walls
 - d) amount of blood in the system
8. Blushing involves dilation in the skin of some of the
 - a) arteries
 - b) veins
 - c) lymph vessels
 - d) capillaries
9. A vein that carries blood with a high oxygen concentration is the
 - a) pulmonary vein
 - b) vena cava
 - c) subclavian vein
 - d) None of the above.
10. Which of the following statements about interstitial fluid is not true?
 - a) It carries both wastes and nutrients between the cells.
 - b) It aids in removing white blood cells from the tissues.
 - c) It is only used by the body when an infection is present.
 - d) It prevents the cells from drying out.

The Structure of the Heart

Fill in the blanks with the correct labels.

14. _____ 1. _____

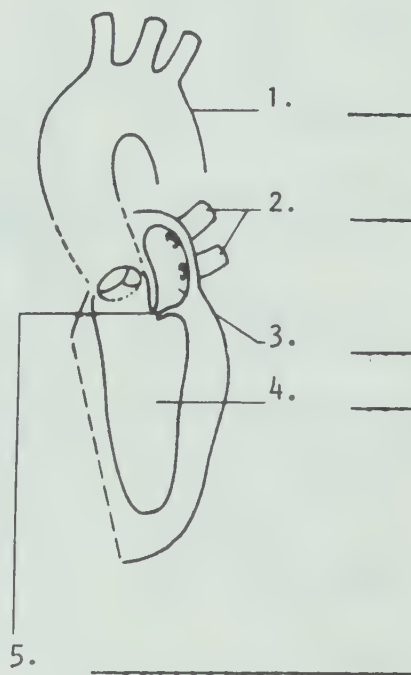
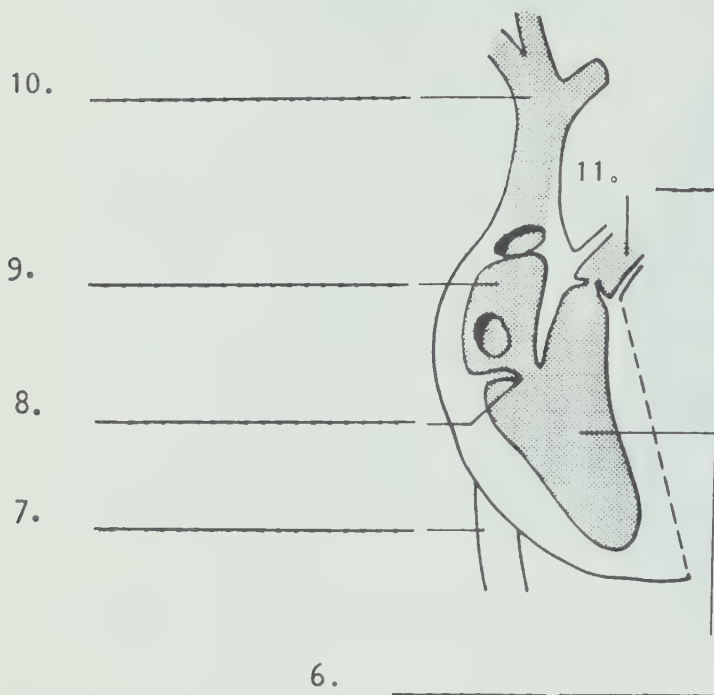


The Two Pumps of the Heart

Fill in the blanks with the correct labels.

RIGHT SIDE OF THE HEART

LEFT SIDE OF THE HEART



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. c) |
| 2. b) | 7. a) |
| 3. b) | 8. d) |
| 4. c) | 9. a) |
| 5. a) | 10. c) |

LABEL ANSWERS TO "THE STRUCTURE OF THE HEART"
(Taken from Figure 10.6, text page 232)

- | | |
|-------------------------------|-------------------------------|
| 1. carotid artery | 8. right ventricle |
| 2. aorta | 9. inferior vena cava |
| 3. left atrium | 10. tricuspid valve |
| 4. pulmonary veins from lungs | 11. bicuspid valve |
| 5. semilunar valves | 12. right atrium |
| 6. left ventricle | 13. pulmonary artery to lungs |
| 7. septum | 14. superior vena cava |

LABEL ANSWERS TO "THE TWO PUMPS OF THE HEART"
(Taken from Figure 10.7, text page 232)

- | | |
|--------------------|------------------------|
| 1. aorta | 7. inferior vena cava |
| 2. pulmonary veins | 8. tricuspid valve |
| 3. left atrium | 9. right atrium |
| 4. left ventricle | 10. superior vena cava |
| 5. bicuspid valve | 11. pulmonary artery |
| 6. right ventricle | |

Selected Readings

1. Arehart-Treichel, J., "Lowering Blood Pressure," *Science News* (May 28, 1977).
2. Benditt, Earl P., "The Origin of Arteriosclerosis," *Scientific American* (February 1977).
3. "Carolina Electrocardiography Manual," (Burlington, N. Carolina: Carolina Biological Supply Co., 1979).
4. "Carolina Human Blood Pressure Manual," (Burlington, N. Carolina: Carolina Biological Supply Co., 1978).
5. Freese, John, *Help Your Heart* (Toronto: Tutor Press, 1978).
6. Heart Foundation (*Provincial*) and the American Heart Association, 44 East 23rd St., New York, N.Y., 10010. For Pamphlets.
7. Jarvik, Robert, "The Total Artificial Heart," *Scientific American* (January 1981).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "The Work of the Heart." 19 min col., EBE
2. "I Am Joe's Heart." 23 min col., Pyramid
3. "The Heart and Circulatory System." 16 min, EBE

FILMSTRIPS

See Chapter 10.

Chapter 11

The Body's Defences against Disease

Chapter Focus

The title of this chapter establishes that the body is an excellent host to many pathogens, but it is also well protected by a variety of defence mechanisms. Knowing the types of attack and the methods by which pathogens enter the body, together with the body's defence systems, it is better to teach general concepts, using a few specific examples to illustrate an idea, rather than to give exhaustive lists of diseases and their symptoms. Basic understandings of vaccination and immunization programmes, allergies, communicable diseases, and how antibiotics work are useful to students.

Objectives

After studying this chapter, the student should be able to

- list the major defences of the body against disease
- define "pathogen" and list the different types of pathogens
- describe the basic structures of the different types of pathogen
- differentiate between infectious and contagious diseases
- describe the major methods by which diseases are transmitted
- define the role of the following defensive agents: white blood cells, histamines, antigens, and antibodies
- define the following terms: natural immunity, artificial or acquired immunity, vaccines, and allergies
- know the general action of prescribed drugs and the action of antibiotics

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
An Excellent Host	*	
Pathogens	*	
Types of Pathogens	*	
Viruses	*	
Bacteria	*	
Rickettsiae		*
Fungi		*
Protozoa		*
Parasitic Worms		*
Transmission of Diseases	*	
Direct Contact	*	
Indirect Contact	*	
Airborne Transmission	*	
Vectors		*
Body Defences	*	
Cellular Defences	*	
Histamines	*	
Antigens and Antibodies	*	
Natural Immunity	*	
Artificial or Acquired Immunity	*	
Allergies	*	
Drugs That Fight Infections		*
Antibiotics		*

Teaching Suggestions

This topic is often omitted from Human Biology courses because it does not follow the pattern of body "systems". Some teachers may prefer to take parts of the chapter and fit them into the topic on blood, particularly the functions of white blood cells. Where it is placed in the course is not important, but the major concepts of the body as an excellent host and how the body repels invaders should be covered somewhere.

While some teachers of Human Biology put a heavy emphasis on disease and health problems that arise in the body, this text is oriented toward a health and fitness approach. However, some teachers may wish to expand this section by having students prepare brief, researched presentations on common ailments. Infectious diseases, such as measles, chickenpox, or the common cold can be used or the more extended disorders such as multiple sclerosis or cancer may be developed. Other combinations are possible.

There is a valid argument supporting some basic home-care instruction within a Human Biology course. Simple home-care of sick children, the treatment of cuts and bruises, or the approach to coping with small emergencies can be incorporated if the teacher wishes. Excellent assistance in developing a short additional section in this area can be obtained from local Health Units.

This chapter provides an excellent opportunity to introduce students to some simple microbiology and microbiological techniques. Every student suffers from infections from time to time, and students need to know how they can

reduce the possibility of infections and how antibiotics and medications help reinforce the body's defences. An understanding of throat cultures, and how the laboratory determines which antibiotic will be the most effective in destroying a particular bacterial strain, is good health science knowledge.

Sexually transmitted diseases are discussed in the chapter on reproduction. However, some teachers may feel that it fits more appropriately into this chapter. The decision to place these infections with the topic of reproduction was based on the feeling that students would be more comfortable asking questions after the general topic of reproduction has been discussed.

Some alternative activities in microbiology are to be found in the B.S.C.S. Yellow Version laboratory manual. Some free literature is also available from the Canadian Cancer Society. An excellent booklet that they supply to schools is entitled "Wild Cells".

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 268)

- | | |
|---------------|---------------|
| 1. phagocyte | 6. vaccine |
| 2. pathogen | 7. allergy |
| 3. contagious | 8. interferon |
| 4. antibodies | 9. antibiotic |
| 5. immunity | 10. toxin |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 268)

1. Viruses are the smallest of all pathogens. They cause diseases such as colds, influenza, and measles. They live within the cells of other organisms. Viruses cannot be controlled easily by drugs. Bacteria are simple, single-celled organisms that reproduce by dividing rapidly. Not all bacteria are pathogenic; some are very useful to man. Bacteria produce poisons that affect the body. There are three basic forms of bacteria.
2. See Figure 11.1, page 254, of the text where some 18 ways are listed.
3. Inflammation is the characteristic redness and swelling that occurs in response to an infection. Capillaries in the infected site relax and increase the blood flow to the area causing the redness. The extra blood results in more heat, which can be easily felt by touching the skin. White blood cells pass more easily through the dilated capillaries to attack the bacteria. The white cells then control the infection by engulfing the bacteria or producing antibodies.
4. Natural immunity may be found in newborn babies who have acquired immunities built up by their mothers and passed on to the babies through the placenta. Such an immunity lasts only a short time. A person who experiences a very mild attack of a disease builds up a resistance to future attacks.

Acquired immunity results from an injection of vaccines of dead or very weak pathogens; the body builds up antibodies to resist any future occurrence of the infection. Antibodies from animals or humans who are immune to the disease can be used to produce immunity.

5. Vaccines from very weak or dead pathogens are injected into the body. These cause only very mild reactions and the body can easily cope with these invaders. The body then produces specific antibodies to these pathogens. Future appearances of the same pathogen are immediately recognized by the body, and it rapidly produces many of the appropriate antibodies to destroy the bacteria and produce immunity to the disease.
6. Examples: dust, drugs, grasses, pollens, fibres, foods, additives, insect stings, cosmetics, etc. Allergies can usually be controlled by antihistamines, given either by injection or in tablet form. Batteries of tests can identify the agent causing the reaction, and then a series of injections can be given to help prevent the reactions recurring. In milder cases, antihistamine tablets can be taken when the reaction starts and these alleviate the symptoms or control the reaction.
7. Direct contact: contact with the pathogen, or person or animal carrying the pathogen; contact with skin, kissing, etc.
Indirect contact: an intermediate object carries the pathogen from one person to another. Examples are water, towels, clothing, cutlery, etc.
Airborne: carried by air currents and breathed in.
Vectors: intermediate hosts, flies, insects, lice. Passed on by bites, or by contact with the feet or mouth parts of the vector insect or animal.
8. White blood cells increase in number as the infection develops. Some white cells surround and destroy the pathogen (phagocytes). Others (lymphocytes) produce antibodies to counter the infection.
9. Contagious diseases: diseases spread by direct or indirect contact.
Infectious diseases: diseases caused by pathogens.
Antibiotic: substance that inhibits the growth or kills bacteria.
Symptoms: characteristics that accompany infections (or other disorders), swelling, pain, high temperature, etc.
Pathogen: disease-causing organism.
10. Maintain good general health. Avoid sudden changes in temperature, or take care to balance the cold with extra clothing. Avoid chills or rapid cooling after exercise. Maintain a good vitamin balance in the diet, especially vitamin C. Avoid close contact with others who have a cold.
Most cold remedies only treat the symptoms of a cold (i.e., help to reduce fever, relieve headaches, dry up nasal discharges, or ease sore throats). They can do little to destroy the virus causing the cold.

Text Activities

In the three activities which involve the culturing of bacteria, teachers must be aware of and practise meticulous sterilization techniques. The personal

cleanliness of students, disinfection of surfaces, and the sterilization of labware must be observed. Careful incineration or the use of an autoclave to destroy cultures after the experiments are complete must be undertaken.

Teachers should demonstrate the techniques to be used (i.e., inoculation of plates) and insist that these techniques are followed by all students.

ACTIVITY 1: WHERE CAN BACTERIA BE FOUND? (TEXT, PAGE 269)

MATERIALS

sterile agar plates, scotch tape, glass-marking pencils

ACTIVITY OBJECTIVES

1. to demonstrate that all surfaces carry bacteria (usually non-pathogenic)
2. to show that bacteria are found in a variety of shapes and colours
3. to show that bacteria can be identified by their shape under a microscope or by the colour of the colony
4. to show that other living organisms are also present all around us and they grow and multiply when given the proper conditions
5. to observe that bacteria grow rapidly and produce very large numbers

PREPARATION TIPS

The technique using scotch tape works well, or sterile Q-tips can be used.

ANSWERS TO QUESTIONS

1. Answers will vary, but will form an excellent basis for discussion.
2. Teachers should help students to identify bacteria colonies. Charts showing the colours of different bacteria colonies are useful. However, the exercise is not to identify specific colonies of bacteria by name. Some characteristics are: size, fuzzy, shiny or dull surfaces, smooth, elevated or flat.
3. Moulds and fungi are usually fluffy or fur-like on the surface. Yeasts are usually white or yellow, often in colonies like bacteria. Bacteria form round, small colonies, frequently smooth and shiny.
4. The conditions are warmth, moisture, a suitable food source, and darkness. Compare these requirements with conditions found in the human body.

ACTIVITY 2: COUNTING BACTERIA IN MILK (TEXT, PAGE 270)

MATERIALS

unsterilized milk from a farmer or dairy, 4 sterile pipettes (capacity 1 or 10 mL), 1 empty sterile flask, 3 sterile flasks containing 99 mL of sterile distilled water each, 3 Petri dishes, flask of warm, liquid lactose nutrient agar.

The above will be needed for each group of students.

ACTIVITY OBJECTIVES

1. to show that bacteria can be found inside living organisms and the products of living organisms
2. to demonstrate the enormous numbers of bacteria present
3. to practise a dilution technique
4. to practise sterilization techniques
5. to demonstrate methods of killing bacteria by heat

PREPARATION TIPS

Some teachers may wish to demonstrate this method. Other teachers may wish to use it as an exercise in following specific directions. However, the students should understand clearly why the dilution is made and the proportions of each dilution in the series. Students should discuss why different pipettes are needed.

ANSWERS TO QUESTIONS

- a) 1 000 000
- b) Numbers will vary and be very large, but it may help if the students understand how small bacteria are.
- c) This must be assumed. Some of the bacteria may be pathogenic. Discuss why with the students.
- d) Research question.
- e) Research question. So often we assign recipe experiments and give students little opportunity to design experiments for themselves. This is an excellent opportunity to provide this experience.

ACTIVITY 3: EFFECTS OF ANTIBIOTICS ON THE GROWTH OF *BACILLUS SUBTILIS* AND *ESCHERICHIA COLI* (TEXT, PAGE 272)

MATERIALS

a disinfectant (such as Lysol), cultures of *B. subtilis*, *E. coli*, sterile nutrient agar plates, glass-marking pencil, forceps, 70% alcohol, inoculating loop, millimetre ruler, Bunsen burner, and commercial antibiotic discs containing tetracycline, penicillin, streptomycin, erythromycin, etc. (Some discs have dispensers)

ACTIVITY OBJECTIVES

1. to show that bacteria growth can be inhibited by some antibiotics
2. to demonstrate that not all antibiotics are effective against all types of bacteria
3. to show that bacteria require certain conditions for growth: warmth, nutrients, and moisture

PREPARATION TIPS

It is wise to clean all lab surfaces with Lysol before starting work. The forceps can be sterilized by flame or with alcohol. Some discs come in spider-shaped arrangements; in this case the experiment can be easily adapted and the plates need not be divided.

ANSWERS TO QUESTIONS

1. The clear areas indicate that the antibiotic has prevented the spread of the bacteria by inhibiting its growth.
2. Answers will vary with the strain of bacteria supplied.
3. Answers will vary according to the strain and specific antibiotics used.
4. Antibiotics are substances that have the power to inhibit growth or destroy bacteria and other organisms. Most antibiotics are made from substances produced from other bacteria, moulds, or fungi.

New techniques using genetic engineering are now successfully adapted by many pharmaceutical houses.

Additional Activities

ACTIVITY 11.A: TO EXAMINE BACTERIA UNDER THE MICROSCOPE

MATERIALS

a disinfectant (such as Lysol), cultures of *Bacillus subtilis* and *Escherichia coli*, glass slides, slide trays, Gram's crystal violet stain, safarin O, iodine, ethyl alcohol, sterile water, inoculating loops, alcohol lamps or Bunsen burners, forceps

METHOD

TRANSFER TECHNIQUE

Your teacher will demonstrate this technique to you first.

1. Light the Bunsen burner or lamp and flame the inoculating loop.
2. Hold the culture at an angle in one hand and withdraw the cotton plug with the fourth and fifth fingers. Do not place the cotton plug on the desk. Hold the loop with the thumb and first fingers. The loop should be no longer glowing and should be sufficiently cool to use. Flame the top of the culture tube. Place the tip of the loop in the culture tube and pick up a sample of bacteria without disturbing the agar.
3. Replace the cotton plug immediately, still holding the loop between the first finger and thumb.
4. Use the loop to inoculate the slide or Petri dish and then sterilize by reflaming the loop.

STAINING BACTERIA ON A SLIDE: GRAM STAIN

1. Polish a clean glass slide with a piece of lens paper. Hold the slide with forceps and pass it through the flame 3 or 4 times.
2. Flame a loop and transfer two small drops of sterile water onto the centre of a glass slide.
3. Using the transfer technique described above, transfer some bacteria onto the slide just beside the drops of water. Mix evenly, using the loop. Flame the loop. Set the slide aside to air dry.
4. When the slide is completely dry, pass it through the flame again with the smear side up. Set the slide on the tray (smear side up) and flood the slide with Gram's crystal violet stain for about 15 to 20 s.
5. Tip off the dye and wash under running water.
6. Flood the slide with iodine and leave for one minute.
7. Tip and drain the slide of iodine and rinse with ethyl alcohol.
8. Rinse again with running water.
9. Flood the slide with safarin O stain for a minute.
10. Rinse under running water. Blot up any wetness on the underside and allow the smear to air dry.

HANDOUT

continued . . .

SAFETY PREPARATIONS

1. See that the desk surfaces are washed off with a weak solution of disinfectant.
2. Wash your hands thoroughly with soap and water before and after the experiments.
3. During the experiments, flame the inoculating loops and needles before and after each use.
4. Soak and clean the slides and equipment in a 10% disinfectant solution.
5. Use the autoclave to destroy all cultures before you discard them.

continued . . .

EXAMINATION OF BACTERIA

1. Place a drop of immersion oil on the centre of the smear on the slide.
2. Carefully swing the 100-power immersion lens into place. Focus the microscope and observe.

OBSERVATIONS AND QUESTIONS

1. Draw the species of the two types of bacteria given to you in this class.
2. Can you observe any pattern or groups among the bacteria?
3. What colour have the bacteria been stained?
4. Are the bacteria living? How can you tell?
5. Compare the two strains of bacteria. In what way do they differ?
6. What conditions are necessary for the growth of bacteria?

ACTIVITY OBJECTIVES

1. to develop microbiological techniques
2. to practise following specific directions
3. to practise maintaining sterile conditions
4. to learn methods of staining and identifying bacteria
5. to examine bacteria under the microscope
6. to establish conditions required for bacterial growth

ANSWERS TO QUESTIONS

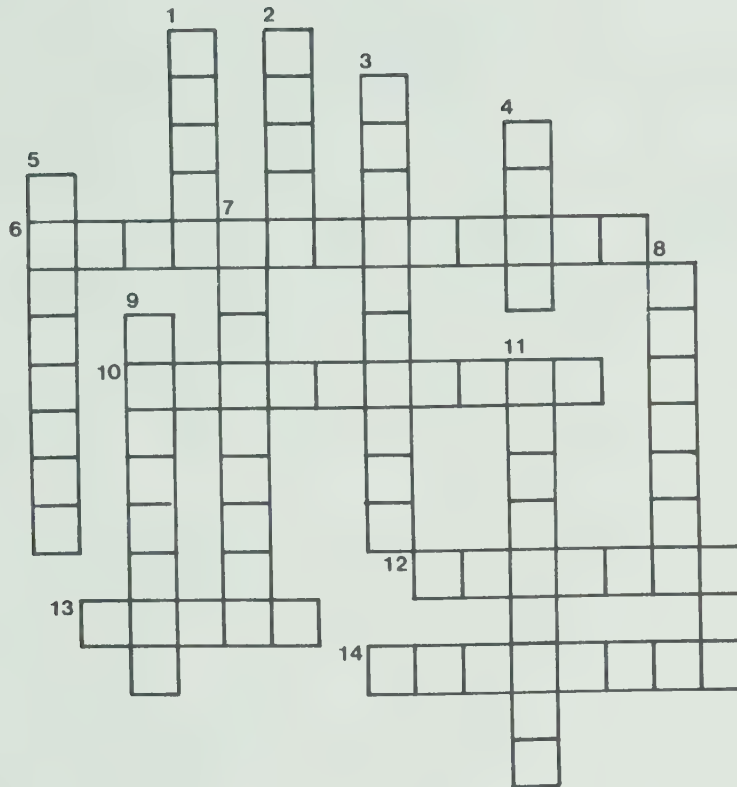
2. Answers will vary according to the type of bacteria supplied.
3. Answers will vary according to the type of bacteria supplied.
4. Bacteria are not likely to be living after this technique. There is no movement or division.
5. Answers will vary according to type of bacteria supplied.
6. Bacteria require a nutrient source, moisture, and an appropriate temperature.

The bacteria used in these experiments are non-pathogenic; that is, they do not cause diseases. However, it is necessary to establish sterile safety techniques and take some elementary precautions.

Self-test: Select the best answer

1. Which of the following are pathogens?
 - a) bacteria
 - b) viruses
 - c) richettsiae
 - d) All the answers are correct.
2. Which of the following are not normally affected by drugs?
 - a) bacilli
 - b) cocci
 - c) viruses
 - d) protozoa
3. Gonorrhea and strep throat are examples of diseases caused by
 - a) viruses
 - b) bacteria
 - c) richettsiae
 - d) protozoa
4. Cocci bacteria are
 - a) round in shape
 - b) rod-shaped
 - c) spiral in shape
 - d) found in many shapes
5. Phagocytes
 - a) produce antibodies
 - b) produce histamines
 - c) engulf and destroy cells
 - d) produce antigens
6. Contagious diseases are
 - a) transmitted by contact with other people who already have the disease
 - b) produced by contact with pathogens
 - c) transmitted by airborne particles
 - d) All of the above are correct.
7. Antibody production occurs in
 - a) the lymph tissue
 - b) the blood
 - c) the skin
 - d) only in wounds
8. Which of the following is not a true statement?
 - a) Each antigen reacts with a specific antibody.
 - b) Antigens are special protein or carbohydrate molecules.
 - c) Antigens stimulate the production of antibodies.
 - d) Antibodies stimulate the production of antigens.
9. Which of the following is not a true statement?
 - a) Babies can acquire immunity from their mothers.
 - b) Immunity is acquired on the first exposure to a disease pathogen.
 - c) Immunity may be acquired by suffering a mild attack of the disease.
 - d) Immunity may be acquired from vaccines.
10. Which of the following is not a true statement?
 - a) Allergic reactions may be genetically inherited.
 - b) A person must have had a previous exposure to an allergy agent.
 - c) Antihistamines are produced in the lymph tissues.
 - d) Histamines are released when antigens and antibodies react producing different symptoms in the body.

Crossword



DOWN

1. type of bacteria that is round in shape
2. athlete's foot is an example of this type of pathogen
3. diseases that you can catch from other people
4. the body's first line of defence against infections
5. a major type of pathogen found in three different shapes
7. substance released in the body during allergy reactions
8. substance that stimulates the production of antibodies
9. any disease-causing organism
11. result of an invasion by pathogens; causes symptoms in the body

ACROSS

6. medication taken to control allergies
10. drug used to combat bacterial infections
12. substance injected to produce immunity
13. symptom that results from many infections
14. substance produced in the body in response to the presence of antigens; helps to combat infections

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. d) | 6. d) |
| 2. c) | 7. a) |
| 3. b) | 8. d) |
| 4. a) | 9. b) |
| 5. c) | 10. c) |

ANSWERS TO CROSSWORD

DOWN

1. cocci
2. fungi
3. contagious
4. skin
5. bacteria
7. histamine
8. antigen
9. pathogen
11. infection

ACROSS

6. antihistamine
10. antibiotic
12. vaccine
13. fever
14. antibody

Additional Resource Material

COMMUNICABLE DISEASES

When a doctor diagnoses a communicable disease, he is required by law to report this to the Medical Officer of Health. In this way, the total number of cases of a particular disease can be plotted and special precautions can be taken if the numbers become epidemic.

Sexually transmitted diseases are not reported by the doctor but by the laboratory that identifies the presence of a pathogen in a culture sent for examination. Since sexually transmitted diseases can be passed on very rapidly from one person to another, special efforts are made to control the spread of these diseases by follow-up interviews. Such programmes protect the health of both infected and non-infected persons, because the presence of the disease is not always recognized by an individual who may, unknowingly, transfer the disease to others. Most venereal diseases are curable and could be wiped out if everyone co-operated and was willing to be treated for these diseases.

When food poisoning cases are reported, food inspectors are brought in to determine how the contamination of the food occurred. If a restaurant was involved, the kitchens and food preparation and storage areas would be examined. If the standards were not satisfactory, the restaurant would be closed until the standards required by the inspectors were met. If the infection came from a can, the total food batch distributed by a particular company involved might be recalled.

Reports are, therefore, very important in obtaining a picture of how far an infection has spread and in protecting the health of persons who have not yet been affected by the disease.

Most local Health Units provide an information sheet for use by school principals. An example is shown on the following page.

TABLE: SOME REPORTABLE COMMUNICABLE DISEASES

1. Anthrax	- acute infection transmitted from hair or hides of sheep (bacteria).
2. Amoebic Dysentery	- ulceration of large intestine, diarrhea (amoeba).
3. Bacillary Dysentery	- inflammation of intestine membrane, ulceration (bacteria).
4. Botulism	- food poisoning (bacteria).
5. Chickenpox	- mild infection usually including rash (virus).
6. Diphtheria	- inflammation of throat, obstructs airways; damage to heart, nerves, kidney (bacteria).
7. German Measles	- especially dangerous during pregnancy; defects in heart, deafness, etc., in fetus (virus).
8. Viral Hepatitis (Infectious)	- inflammation of liver, enters digestive tract (virus).
9. Viral Hepatitis (Serum)	- enters blood (needles, etc.); jaundice, damage to liver cells (virus).
10. Measles	- respiratory inflammation, fever, rash; complications: inflammation of spinal cord and brain (virus).
11. Mumps	- swollen glands; complications: inflammation of testes (virus).
12. Poliomyelitis	- affects spinal cord; paralysis (virus).

13. Psittacosis - disease contracted from parrots; chills, fever, rash, complications (virus).
14. Rabies - fatal in 50% of cases if not treated; from saliva of infected animal (virus).
15. Rocky Mountain Spotted Fever - tick-borne disease common in U.S.; fever, hemorrhagic rash; can be fatal (virus).
16. Salmonella - food poison; propagated in contaminated food; serious gastro-intestinal disturbance (bacteria).
17. Tetanus - often fatal poisoning if bacteria enter deep wounds (bacteria).
18. Tuberculosis - infectious; can affect any age group, usually in the lung (bacteria).
19. Typhoid Fever - general infection; rash spots on skin, ulcers (bacteria).
20. Typhus Fever - insect-borne disease; headache, rash, delirium; often fatal (bacteria).
21. Whooping Cough - infection of trachea and bronchi (bacteria).

THE PUBLIC HEALTH ACT RE COMMUNICABLE DISEASES. 1972

Most local Health Units provide an information sheet for use by school principals. Here is an example.

INFORMATION ON COMMUNICABLE DISEASES.

When a principal has reason to suspect that a pupil has a communicable disease, he should *exclude* the pupil until he is satisfied that it is safe for the student to return.

The pupil who has a communicable disease may return to school when the minimum period of isolation has expired.

The following schedule sets out the periods of isolation and quarantine for some common communicable diseases.

TABLE: COMMUNICABLE DISEASES

Disease	Period of Isolation of Patient	Quarantine of Contacts	Incubation Period
Chickenpox	7 d from appearance of the blisters (or until the lesions have healed, whichever is the longer).	From school and non-immune persons	2-3 weeks commonly 13-17 d
German Measles (Rubella)	5 d from the onset of the disease.	None	14-21 days usually 18 d
Red Measles (Rubeola)	7 d after the appearance of the rash.	None	8-13 days usually 10 d
Mumps	Until the swelling (glands) has completely subsided (usually 7-9 d).	None	12-16 days usually 18 d

Disease	Period of Isolation of Patient	Quarantine of Contacts	Incubation Period
Infectious Hepatitis	During first two weeks of illness and at least 7 d after the onset of jaundice.	None	10-50 days (30-35 d most common)
Whooping Cough	3 weeks from onset.	Under 12 years of age. If not immunized and no previous attack, 3 weeks	7-21 days usually 10 d

THE COMMON COLD

The common cold causes more absenteeism from school or work than any other infection, and as yet there is no really effective treatment to combat this ailment.

Colds are caused by viruses. At least 90 different viruses are believed to be involved. Symptoms of the common cold are well known: sneezing, runny or stuffed up nose, sore throat, coughing, and watery eyes. Usually we feel cold or shivery even at normal temperatures but a high fever is not common. This symptom is more often produced by some other infection caught subsequent to the initial cold.

Viruses which cause the common cold are transferred by droplets produced by sneezing and coughing or by direct contact with an infected person or the utensils he or she has been using.

Environmental changes can also produce colds. If you are very warm after exercise and then stand about and get chilled, the mucous membranes in the nose may be dilated and give access to pathogens that would normally be prevented from entering the body.

It is almost impossible to prevent colds. The best defence is to keep fit so that your body will be in the best fighting condition to resist infections. Obviously it makes sense to avoid contact with other people who have had colds. Taking sensible precautions involves good nutrition, adequate amounts of sleep, taking care not to become overheated or chilled, and dressing properly and appropriately for the weather.

Most of the remedies that are advertised for colds only treat the symptoms of a cold and they do little or nothing to actually destroy the viruses that are present in the body. Vitamin C has been claimed by some experts to have a valuable effect on producing resistance to colds. Other medical opinions state there is no validity in these claims. However, a lack of vitamin C in the diet may well reduce the individual's resistance to colds.

TABLE: IMMUNIZATION

A schedule of recommended vaccines to protect you against a number of potentially dangerous diseases.	
2 months	First immunization. Four vaccines in one against diptheria, whooping cough, tetanus and polio
4 months and 6 months	Two more injections against diptheria, whooping cough, tetanus and polio
12 months	One injection of a combined vaccine against measles, mumps and rubella (German measles)
16 to 18 months	First booster dose of vaccine against diptheria, whooping cough, tetanus and polio
4 to 6 years	Second booster dose against diptheria, whooping cough, tetanus and polio
11 to 12 years	Third booster dose against diptheria, tetanus and polio
16 to 18 years	Fourth booster dose against diptheria, tetanus and polio
Adults	Polio vaccine every five years. Tetanus vaccine booster every ten years. Women planning a family should have their immunization updated, including rubella immunization, before becoming pregnant. Where children have not been immunized from early childhood, a modified immunization program should be decided upon, in consultation with the doctor or local health unit.

Source: Ontario's Recommended Immunization Schedule. By permission of the Ontario Ministry of Health.

Selected Readings

1. Arehart-Treichel, Joan, "Antibodies Tie Up Malarial Parasite," *Science News* (January 17, 1981).
2. Burke, Derek C., "The Status of Interferon," *Scientific American* (April 1977).
3. Capra, Donald J. and Allen Edmundson, "The Antibody Combining Site," *Scientific American* (January 1977).
4. Clark, M., "Early Warnings on Disease," *Newsweek* (July 9, 1979).
5. Cochran, Neal P., "Cell Surface Immunology," *Scientific American* (May 1976).
6. "Molecule Suppresses Allergic Reactions," *Science News* (March 11, 1978).
7. Old, Lloyd J., "Cancer Immunology," *Scientific American* (May 1977).
8. Raff, Martin C., "Cell-Surface Immunology," *Scientific American* (May 1976).
9. Rose, Noel R., "Autoimmune Diseases," *Scientific American* (February 1981).
10. "Stress May Damage Cell Immunity," *Science News* (March 11, 1978).
11. Toufexis, Anastasia, "Heart Attacks," *Time Magazine* (June 1, 1981).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Body Defenses Against Diseases." 14 min col., EBE
2. "Bacteria." 19 min col., EBE

SLIDES

Microslide System. See Wards (Arbor Scientific Catalog, Ont.).

1. "The Virus."
2. "Animal Parasites of Man."

Unit VI

How the Body Exchanges Oxygen and Carbon Dioxide

Chapter 12

Breathing

Chapter Focus

Students may tend to concentrate on the names and general functions of parts of the respiratory system, thereby losing sight of the primary need in the body for oxygen at the cellular level. During cellular respiration, oxygen is needed to oxidize sugars within the mitochondria of every cell. Therefore, oxygen must be delivered not just to the lungs, but to every cell within the body. Breathing is thus the first step. The circulatory system delivers the oxygen to the cells.

Breathing is also an excretory process by which carbon dioxide is removed from the cells and body fluids before it reaches toxic proportions.

Objectives

After studying this chapter, the student should be able to

- define the need for a respiratory system in the human body
- label a diagram of the respiratory system
- describe the structures and functions of the respiratory system
- describe what happens to clean, moisten, and warm air as it passes into the body
- know the major respiratory diseases and how they affect the body
- describe the mechanism of breathing and the principles involved
- define the four volumes involved in lung capacity and know how these volumes are measured
- explain how oxygen and carbon dioxide are exchanged in the alveoli
- explain how oxygen is carried in the blood
- describe how the rate of breathing is controlled by the nervous system
- demonstrate that he or she can provide basic rescue breathing
- know respiratory problems that arise from smoking and the effects of tobacco smoke

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Need for Oxygen	*	
The Air-Conducting Structures	*	
The Nasal Cavity	*	
The Pharynx	*	
The Larynx and Epiglottis	*	
The Trachea and Bronchi	*	
The Lungs and Pleura	*	
The Mechanism of Breathing	*	
Lung Capacity		*
The Exchange of Gases	*	
Control of the Amount of Oxygen Delivered		*
Smoking		optional
The Effects of Tobacco Smoke		optional
Lung Disease and Smoking		optional

Teaching Suggestions

Most of this chapter is straightforward. However, models of the trachea, esophagus, and epiglottis are useful to have. A skull that shows the nasal septum and the fine bones within the nasal cavity is also helpful.

The most difficult part for the students to grasp is the size of the alveoli and the location of the capillaries in the thin walls of these very tiny sacs. A visual presentation which helps is to place an inflated balloon inside a string onion bag. The balloon represents the alveolus and the strings of the bag represents the capillaries surrounding the air sac. A section through the alveoli wall and the capillary wall is important to show that the gases must diffuse through two squamous epithelial cells (alveolus and capillary) in order to enter the blood stream.

Smoking

Some teachers will leave this section to the health classes taught by the Physical Education instructors. However, these teachers usually don't have access to equipment or laboratory apparatus that can demonstrate the effects of smoking on the body. Science teachers can help to reinforce the work of other departments by specific experiments, or they may choose to complete the topic themselves. The experiments in this section will show that students who do smoke get significantly different results from students who are non-smokers.

A method that has proved successful is to have the students summarize all their individual results on one master overhead transparency. Resting and active breathing rates, pulse rates, vital capacity, hand and skin temperatures, and blood pressure are recorded.

When these results are summarized on the screen (without names), the teacher or the class can often identify the smokers in the class with considerable accuracy. Students with respiratory disorders will also show up in these results. Such an objective indication of how smoking affects the

bodies of quite young and light smokers can be a powerful incentive to smokers to give up the habit. If the results are approached with tact and understanding, the results are well accepted by students without any judgments being expressed.

Discussion on the rights of smokers and non-smokers can be effectively introduced by having a person from the Lung Association come to the school and test the students with a carbon monoxide meter. Recently, during a visit from such a resource person, the results of two students suggested that they had recently smoked a cigarette. The students were both adamant that this was not the case. After some discussion and investigation it was found that both students had been seated next to smokers on a school bus and had inhaled second-hand smoke. The carbon monoxide inhaled showed up on the meter about two hours later.

The Lung Association in most areas is very happy to come into the school and bring films and speakers to reinforce the classroom teaching programme. The Canadian Cancer Society will also supply the teacher with a set of 35 mm slides and overheads that are very useful in teaching this section.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 292)

- | | |
|-------------------|--------------------|
| 1. alveoli | 6. medulla |
| 2. intercostals | 7. pharynx |
| 3. bronchi | 8. diaphragm |
| 4. pleura | 9. larynx |
| 5. vital capacity | 10. carbon dioxide |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 292)

1. The sequence of structures through which a molecule of air would pass are nostrils, nasal chamber, nasal pharynx, trachea, bronchi, bronchioles, and alveoli.
2. The intercostal muscles raise the ribs upward and outward. The diaphragm is contracted and is flattened. Both of these movements increase the volume of the thoracic cavity. This decreases the pressure and causes the air to rush into the lungs and equalize the pressure.
3. Inspiratory reserve volume: the amount of extra air that can be drawn into the lungs after a normal inhalation
Expiratory reserve volume: the amount of extra air that can be forcibly expelled after a normal exhalation
Tidal volume: the amount of air that passes in or out of the lungs during normal quiet breathing
Vital capacity: the total amount of air in the lungs, exclusive of the residual air. The sum of the three active volumes (i.e., inspiratory reserve volume + expiratory reserve volume + tidal volume)
5. The visceral pleura isolate the lungs from each other. A fluid bathes

and lubricates these surfaces preventing rubbing friction. The parietal pleura adhere to the thoracic walls and thus are pulled outward as the muscles attached to the ribs contract during inspiration.

6. Three processes occur in the nasal chamber. Incoming air is warmed, moistened, and cleaned before entering the airways.
7. The larynx is the voicebox. It consists of two flaps of cartilage controlled by muscles which are called the vocal cords. As air passes out over these cords, they vibrate and sound is produced.
8. Smoking affects the respiratory system by destroying or preventing the action of the cilia along the airway walls. It leaves clogging and potentially cancer-inducing compounds within the lungs. Chemical compounds in smoke affect respiratory and heart rates, constrict blood vessels and decrease the temperature in the hands and feet. These compounds also increase blood pressure as well as inducing or increasing many respiratory disorders.

Text Activities

ACTIVITY 1: HOW DOES THE AIR ENTERING THE LUNGS DIFFER FROM AIR LEAVING THE LUNGS? (TEXT, PAGE 293)

MATERIALS

thermometer, glass plate, test tube, limewater, straw, isopropyl alcohol

ACTIVITY OBJECTIVES

1. to demonstrate that carbon dioxide is excreted when we exhale
2. to show that air is warmed as it enters the body (energy loss)
3. to show that air is moistened as it enters the body (water loss)

ANSWERS TO QUESTIONS

1. Air is warmed and moistened as it enters the body and the composition of the gases in the inhaled air changes.
2. The turbinate bones increase the surface area of the nasal cavity. These structures are covered by membranes rich in blood vessels, which enable the warming and moistening to take place.
3. The exchange of CO_2 and O_2 takes place in the alveoli of the lungs.

ACTIVITY 2: THE RATE OF RESPIRATION (TEXT, PAGE 294)

ACTIVITY OBJECTIVES

1. to demonstrate that oxygen requirements increase with activity
2. to observe that breathing rates are affected by position, posture, tension, excitement, smoking, fitness, and respiratory disorders

ANSWERS TO QUESTIONS

1. If a person is conscious of his or her breathing, the rate changes.
2. Results will vary. Often a pattern emerges that shows a slower breathing rate among students who exercise regularly and a faster rate among smokers.

ACTIVITY 3: MEASURING THE CAPACITY OF THE LUNGS (TEXT, PAGE 294)

MATERIALS

spirometer

ACTIVITY OBJECTIVES

1. to determine the volume required during normal breathing
2. to determine individuals' vital capacities
3. to discuss what causes variations among students
4. to discuss respiratory disorders
5. to understand the effects of exercise, age, smoking, etc. on lung capacity

PREPARATION TIPS

Techniques will vary according to the type of respirometer used. Students must be encouraged to empty their lungs completely during the vital capacity test. A competitive element will sometimes encourage this.

Students who are small in stature are sometimes concerned by lower capacities than other students. It is important to reassure them that the volume of their chests, compared to other taller students, is normal.

ACTIVITY 4: WHAT EFFECT DOES SMOKING HAVE ON THE PULSE RATE, RESPIRATION RATE AND BLOOD PRESSURE? (TEXT, PAGE 296)

MATERIALS

sphygmomanometer, thermometer, cigarettes

ACTIVITY OBJECTIVES

1. to demonstrate that smoking does produce measurable physiological changes in the body
2. to determine that smoking increases blood pressure
3. to observe that smoking reduces the temperature in the extremities
4. to observe that pulse rate increases with smoking

ANSWERS TO QUESTIONS

1. See "Activity Objectives".
2. Nicotine constricts blood vessels and lowers the skin temperature in the hands. This constriction also increases blood pressure.
3. Nicotine causes changes in the heart and respiratory rates.

ACTIVITY 5: EXAMINE THE EFFECTIVENESS OF A FILTER IN A CIGARETTE
(TEXT, PAGE 296)

MATERIALS

smoking apparatus, cigarettes

ACTIVITY OBJECTIVES

1. to observe that cigarettes contain tars and other chemicals (brown stains)
2. to show that filters do not take out very much of these substances
3. to determine that the length of a filter would have to be increased enormously in order for the filter to be effective
4. to conclude that the quantity of tars varies from one brand of cigarette to another, but not always in the way that is expected from the advertising statements

PREPARATION TIPS

This experiment may be combined with Activity 7.

The Eduquip apparatus works well, but a simple demonstration apparatus can be made from two funnels taped back to back (see figure on next page). One funnel will have a small hand squeeze bulb or a small, low-pressure aquarium pump attached. The other funnel will require a short piece of tube into which a cigarette can be inserted with a tight fit.

ACTIVITY 6: DEMONSTRATE THE SUBSTANCES CONTAINED IN CIGARETTE
SMOKE (TEXT, PAGE 297)

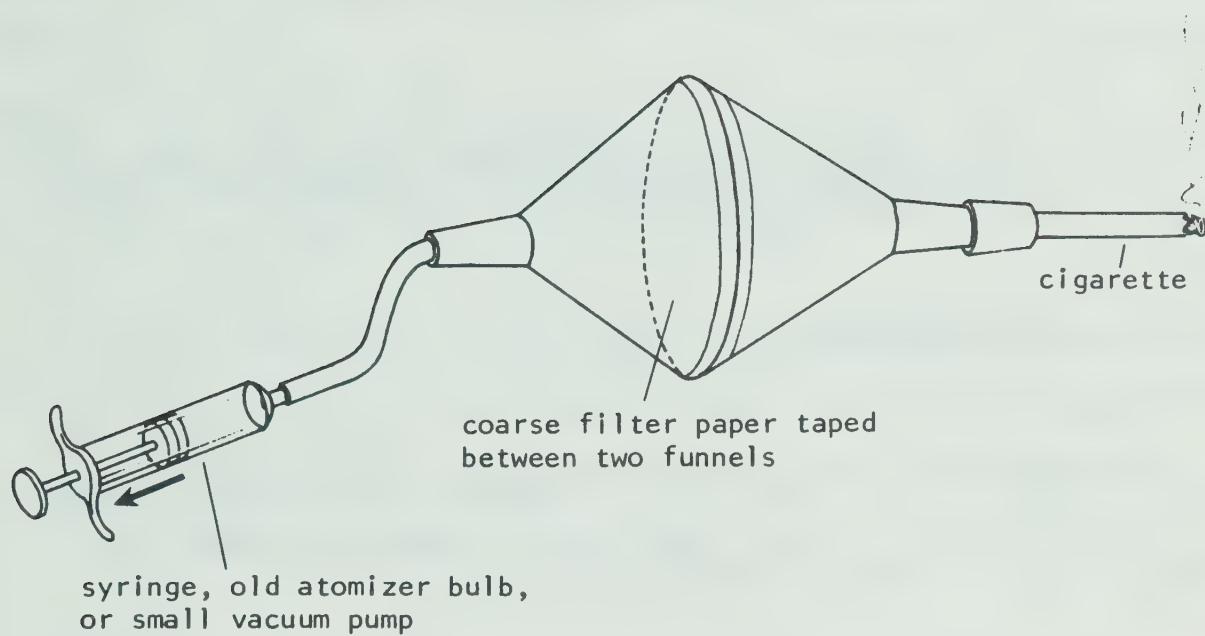
MATERIALS

paper tissues, cigarettes

ACTIVITY OBJECTIVES

1. to demonstrate that smoke contains compounds including tars
2. to show that many of the compounds are retained in the lungs and not exhaled

Figure: Simple smoking apparatus for experiment if Eduquip apparatus is not available.



ACTIVITY 7: COMPARISON OF DIFFERENT BRANDS OF CIGARETTE AND THE EFFICIENCY OF THE FILTERS (TEXT, PAGE 297)

MATERIALS

smoking machine, filter paper, different brands of cigarettes

Refer to Activity 5 for notes.

ACTIVITY 8: WHICH HALF OF THE CIGARETTE HAS THE MOST TARS: THE FIRST OR THE SECOND HALF OF THE CIGARETTE? (TEXT, PAGE 298)

MATERIALS

smoking machine and cigarettes

ACTIVITY OBJECTIVES

1. to demonstrate that tars accumulate in the part of the cigarette closest to the filter
2. to observe that more tars are drawn into the lungs while smoking the second half of a cigarette than the first half

Additional Activities

ACTIVITY 12.A: THE SOUNDS OF BREATHING

MATERIALS

stethoscope

METHOD

1. Using a stethoscope, listen to the sounds of breathing. While your partner is sitting quietly, place the stethoscope bell over the larynx, trachea, the front, back, and sides of the chest.
2. Have your partner exercise vigorously for at least two minutes (run in place, push ups, etc.). Listen again at the locations listed.
3. Allow a few minutes for recovery, and then listen while your partner is talking and coughing.
4. Briefly describe what you heard.

ACTIVITY OBJECTIVES

1. to observe that breathing sounds can be heard in several chest locations with the use of a stethoscope
2. to recognize that abnormal sounds can be distinguished for diagnostic purposes

PREPARATION TIPS

Teachers should be vigilant during this experiment to see that students are using sensible caution and not becoming unnecessarily dizzy.

Using the stethoscope requires a quiet room. Often, a classroom with many students makes it difficult to hear the sounds clearly. If you cannot make other arrangements, such as using the science prep room, have the students breathe deeply or run in place for a few seconds. Sounds can be heard quite clearly through a thin blouse or shirt, but not through a sweater or heavy material. Warn students to come to class prepared on the day of the experiment. Remind the students to keep the tubes away from clothing or from touching each other; this produces static sounds and makes it more difficult to distinguish the breathing sounds.

ACTIVITY 12.B: THE EFFECT OF CARBON DIOXIDE LEVELS ON THE RESPIRATORY CENTRE

MATERIALS

paper bag, beakers, straws, water

DISCUSSION

Deep, rapid breathing, or hyperventilation, clears much of the CO_2 from the blood and increases the amount of oxygen present. Hyperventilation may produce dizziness. In this experiment if you feel particularly dizzy, discontinue hyperventilating and sit down.

METHOD

1. Breathe normally for two or three minutes and then see how long you can hold your breath. In your notebook, record the length of time that you held your breath.
2. Try this again, but this time have a straw in your mouth with the other end in a beaker of water. Breathe quietly in (a normal breath), then hold it as long as you can. Just before you feel that you must take a breath start to sip the water. Record the time that passed from the time you drew in the quiet breath to the point when you had to take a second breath.
3. Hyperventilate rapidly and deeply 20 times. Time how long you can hold your breath after hyperventilating.
4. Hyperventilate again 20 times, but this time place a paper bag over your nose and mouth so that you are re-using the same air. Time how long you can hold your breath and record your results.
5. Exercise vigorously by running up and down some stairs or running around the building. Find out how long you can hold your breath after exercise.
6. List all your recorded results and explain why the times are different in each case. Remember that the respiratory centre is very sensitive to changes in carbon dioxide content in the blood. Why is there a feeling of not needing to breathe for a while after hyperventilating?

ACTIVITY OBJECTIVES

1. to observe that the amount of carbon dioxide in the blood triggers the breathing response and determines the breathing rate
2. to determine that low oxygen and high carbon dioxide levels increase the respiration rate
3. to show that high levels of oxygen after hyperventilation reduce the breathing rate
4. to show that vigorous exercise increases the oxygen debt

PREPARATION TIPS

Teachers should be vigilant during this experiment to see that students are using sensible caution and not becoming unnecessarily dizzy.

ANSWERS TO QUESTIONS

1. Answers and rates will vary quite widely.
and 2.
3. Hyperventilating should increase the breath-holding time.
4. Hyperventilating with air higher in CO_2 content and lower in O_2 content will reduce breath-holding time.
5. Exercise increases the demand for oxygen and the level of CO_2 in the blood, thereby increasing the breathing rate.
6. The feeling of not needing to breathe is due to the excess oxygen in the blood which is supplying current needs. Lower levels of CO_2 are not triggering the nervous respiratory rate centre.

ACTIVITY 12.C: THE PHYSIOLOGY OF RESPIRATION

Discover the changes in chest measurements that take place during respiration.

MATERIALS

tape measure, chest calipers

During respiration, the contraction of the intercostal muscles and the diaphragm cause the volume of the thoracic cavity to increase. This results in air flowing into the lung cavity to equalize the pressure. During expiration, the muscles relax and reduce the size of the cavity, thus increasing the pressure and causing the air to be forced out of the lungs.

METHOD

1. Using a tape measure, determine the circumference of the chest in centimetres. Place the tape around the chest as high up under the armpits as possible. Make sure that the tape is level all the way round (not high at the front and low at the back). Make the measurements
 - a) after a quiet inspiration,
 - b) after a quiet expiration,
 - c) after the deepest inspiration,
 - d) after a forced expiration.
2. Record the data in a suitable table.
3. To find the diameter of the chest, use a pair of calipers. The calipers must open wide enough to measure the width of the chest. (If the proper calipers are not available, a quite adequate substitute can be made from a piece of heavy cardboard or masonite. The opening can be measured against a ruler.) Measure the diameter of the chest from front to back and from side to side. Measure at the nipple line which is the widest part of the thorax. Make a table and record your results for the diameter after
 - a) a quiet inspiration,
 - b) a quiet expiration,
 - c) a forced inspiration,
 - d) a forced expiration.
4. The THORACIC INDEX is the ratio of the front-to-back diameter over the side-to-side diameter.
Using the measurements for normal, quiet inspiration, express the two measurements as a ratio. The front-to-back diameter is usually about 67% of the side-to-side diameter.
5. Compare your results with the results of other students in the class. You might make a table on the chalkboard. Try to discover if there is any correlation between those students who have large ratios and those students who exercise a great deal. Consider if the body size or smoking

continued . . .

make any difference.

6. Decide if the abdomen goes "in" or "out" during respiration. Determine if your answer was correct or not by measuring the diameter of the abdomen during heavy breathing.

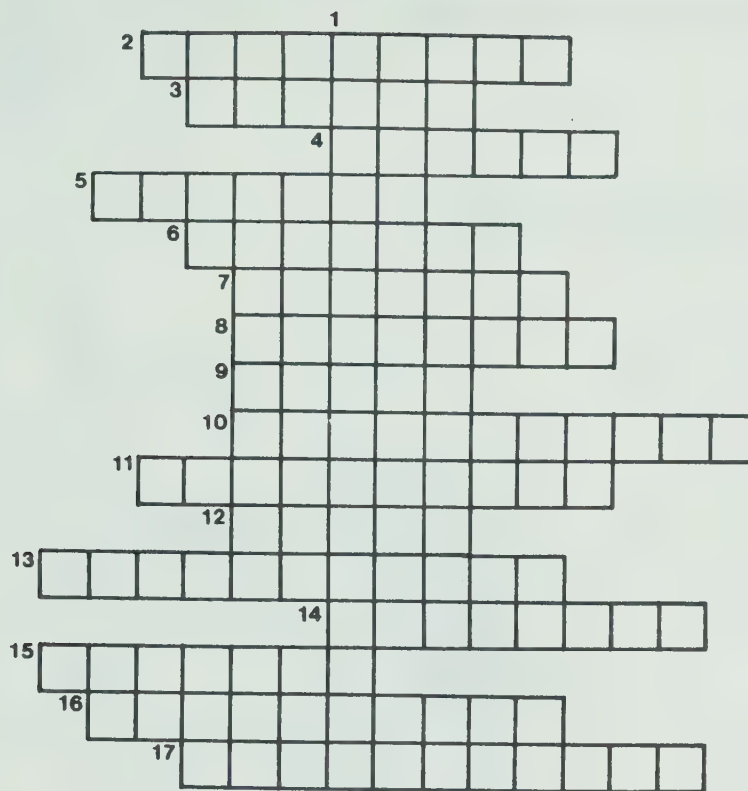
ACTIVITY OBJECTIVES

1. to observe that chest movements during inhalation increase in a forward-and-upward motion, and lateral measurements remain relatively constant
2. to observe that abdominal movements increase slightly anteriorly due to the forward position of the base of the sternum, and lateral movements are slight
3. to show the chest expansion measurement is directly related to vital capacity
4. to demonstrate that although the size of the chest varies among individuals, the thoracic ratio remains relatively constant

Self-test: Select the best answer

1. Oxygen and carbon dioxide cross the membranes between the capillaries and the alveoli by the process of
 - a) osmosis
 - b) filtration
 - c) diffusion
 - d) active transport
2. The volume of air moving in and out of the lungs during normal breathing is called
 - a) expiratory reserve volume
 - b) inspiratory reserve volume
 - c) tidal volume
 - d) vital capacity
3. The surface of the lung is in contact with a membrane called the
 - a) mesentery
 - b) viscera
 - c) pleura
 - d) pericardium
4. The respiratory centre that responds to changes in carbon dioxide and oxygen levels in the blood is found in the
 - a) lungs
 - b) brain
 - c) esophagus
 - d) trachea
5. The pharynx opens into
 - a) the nasal chamber
 - b) the mouth
 - c) the esophagus
 - d) the trachea
 - e) All of these.
6. Tonsils and adenoids are composed of
 - a) fat tissue
 - b) lymph tissue
 - c) muscle
 - d) glands
 - e) epithelium
7. The exchange of gases takes place in the
 - a) alveoli
 - b) trachea
 - c) bronchioles
 - d) All of these are correct.
8. Rings of cartilage are found in
 - a) the trachea
 - b) the bronchi
 - c) the pharynx
 - d) Both a) and b) are correct.
9. Both food and air pass through the
 - a) trachea
 - b) esophagus
 - c) larynx
 - d) pharynx
10. Oxygen is carried in the blood stream primarily by
 - a) whole blood
 - b) hemoglobin
 - c) plasma
 - d) blood proteins

Crossword



DOWN

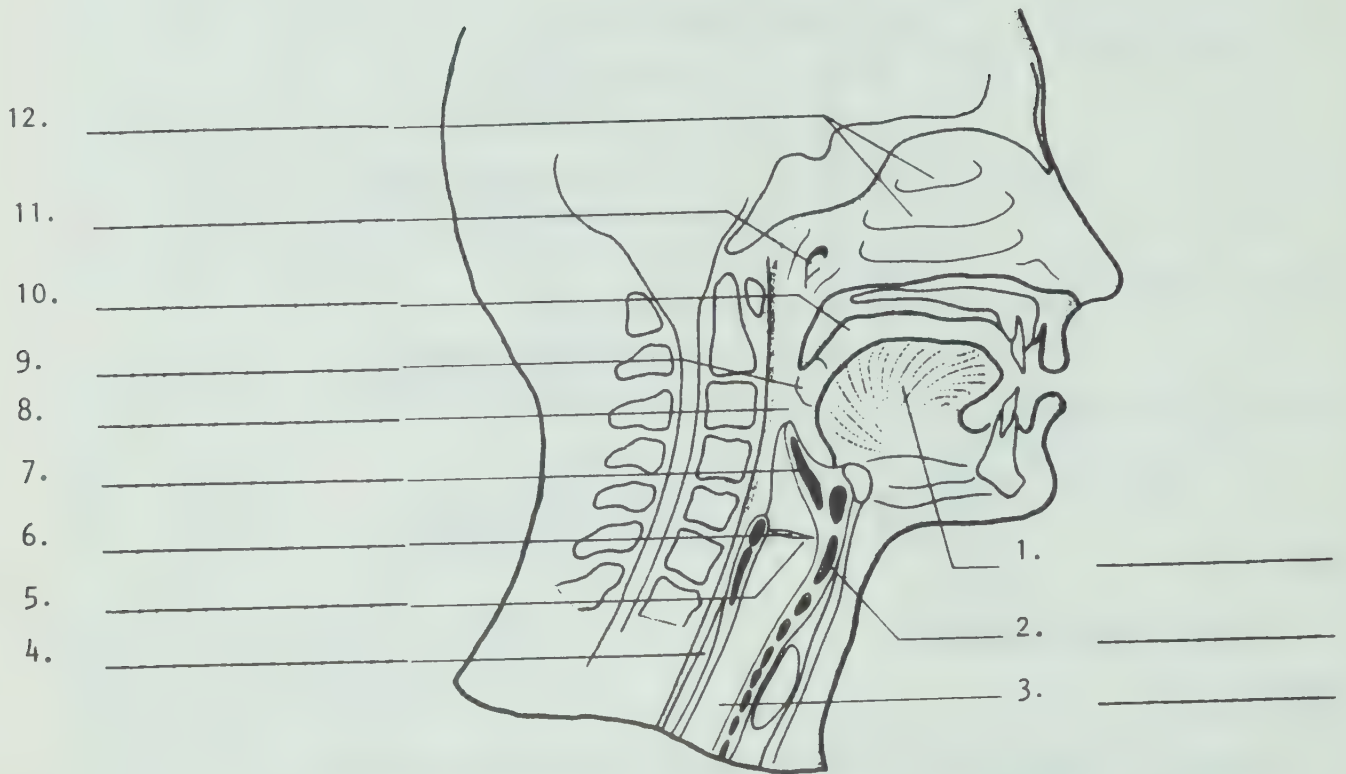
1. rapid, deep breathing

ACROSS

2. sheet of muscle between the thoracic and abdominal cavities
3. contains the vocal cords
4. membranes around the lungs
5. tube in the neck with rings of cartilage
6. short tube that connects the mouth and nose cavities
7. air sacs
8. when the volume of the chest cavity increases, this decreases
9. main respiratory organs
10. muscles between the ribs
11. thin bones found in the nasal chamber
12. tiny hairs on the cells lining the upper respiratory surfaces
13. tiny vessels surrounding the alveoli
14. cavity in which lungs are found
15. two branching tubes from the trachea
16. keeps food from entering the trachea
17. small tubes carrying air inside the lungs

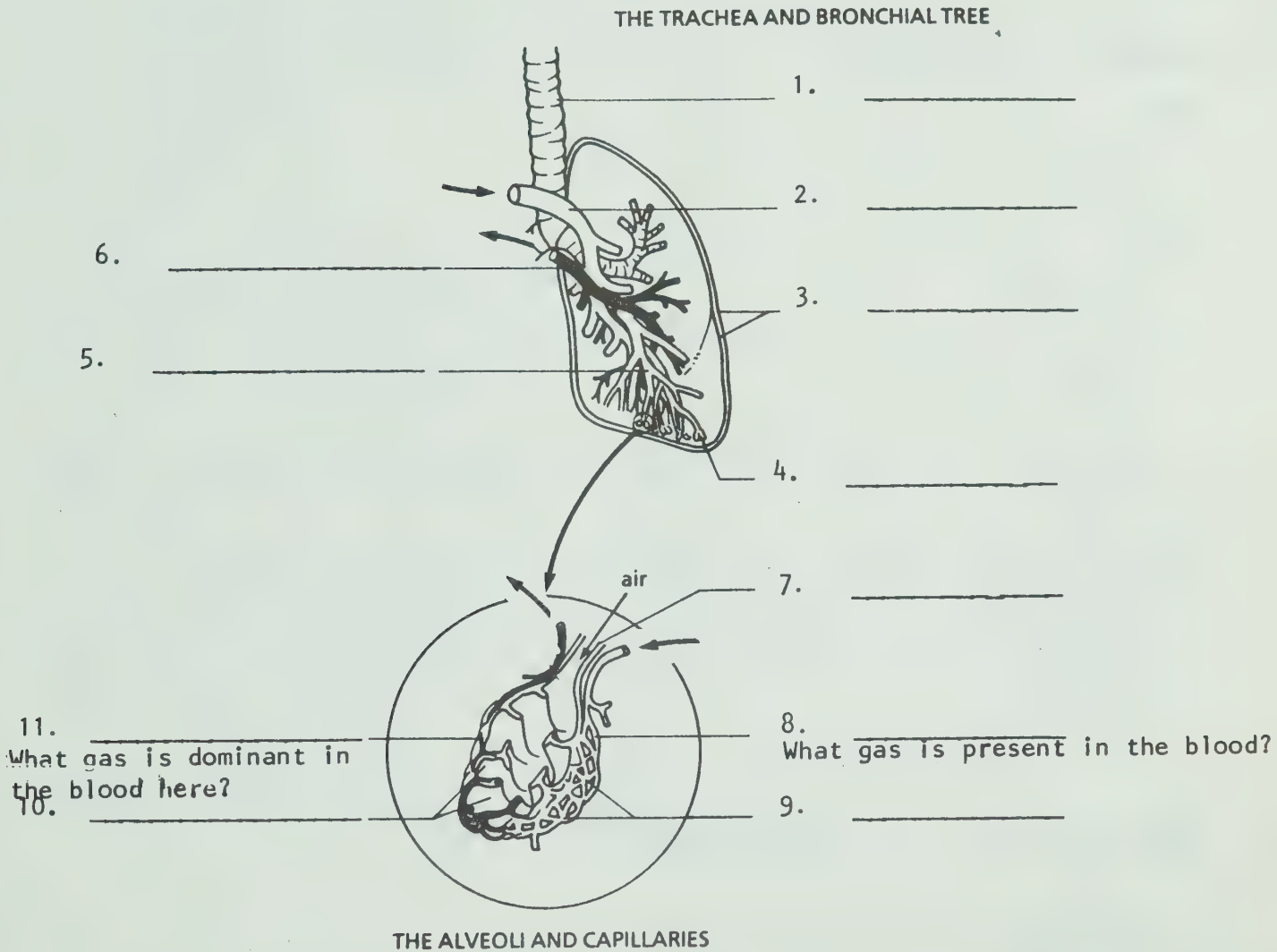
The Nose and Mouth Cavities

Fill in the blanks with the correct labels.



The Trachea and Bronchial Tree/Alveoli and Capillaries

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. c) | 6. b) |
| 2. c) | 7. a) |
| 3. c) | 8. d) |
| 4. b) | 9. d) |
| 5. e) | 10. b) |

ANSWERS TO CROSSWORD

DOWN

1. hyperventilation

ACROSS

2. diaphragm
3. larynx
4. pleura
5. trachea
6. pharynx
7. alveoli
8. pressure
9. lungs
10. intercostal
11. turbinates
12. cilia
13. capillaries
14. thoracic
15. bronchi
16. epiglottis
17. bronchioles

LABEL ANSWERS TO "THE NOSE AND MOUTH CAVITIES"
(Taken from Figure 12.1, text page 276)

1. tongue
2. cartilage
3. trachea
4. esophagus
5. larynx
6. vocal cords
7. epiglottis
8. oral pharynx
9. tonsil
10. oral cavity
11. opening of eustachian tube
12. wall of nasal cavity and turbinates

LABEL ANSWERS TO "THE TRACHEA AND BRONCHIAL TREE/ALVEOLI AND CAPILLARIES"

(Taken from Figure 12.3, text page 279)

1. trachea
2. pulmonary artery
3. the pleura
4. alveoli
5. bronchioles
6. pulmonary veins
7. bronchiole
8. carbon dioxide
9. capillaries
10. alveoli
11. oxygen

Additional Resource Material

CASE STUDY David, 17 years (text, page 288-289)

Water Safety and Rescue Breathing

This case study will help to get a discussion started, or can be used as a homework assignment with questions or with students researching some aspect of the topic.

Teachers will find that, on this topic, there are many student "experts"; that is, students who are qualified life guards or instructors at YMCA swimming classes. However, many students are not familiar with even the basic techniques of handling a swimming accident, and this is an important life skill. (One local medical doctor who read over the case study after it was written, was not aware that mouth-to-mouth techniques can be employed while the victim is still in the water.)

Some teachers include some practical First Aid in their Human Biology course. Life-saving techniques, if taught, can often be judged by qualified students in the class.

SOME SUGGESTIONS ON HOW TO STOP SMOKING

Look over this list and see if there are some methods that might help you. You may wish to adopt several of these ideas, jot them down, and work out a plan of attack.

1. Decide whether you are going to stop suddenly or gradually. If it is to be a gradual process, work out a tapering-off programme for yourself.
2. Don't keep a store of cigarettes. Avoid buying by the carton. Wait until you finish a packet before you buy the next.
3. Don't carry your cigarettes around, leave them in a place where it is trouble to get them.
4. Try an alternative to smoking such as chewing gum. Do something different when you feel like a smoke. Take a short walk or shoot a few basketball hoops.
5. Some people find that if they suddenly double their normal number of cigarettes per day that they become nauseated by the taste, and the idea of smoking becomes quite revolting. Try this and then try to stop completely.
6. Make a list of all the reasons why you should stop smoking and the reasons why you think that it is a bad habit. Post it up somewhere where you can see it and be reminded of the reasons frequently.
7. Make up a list of dates and small rewards that you will treat yourself to if you stay off smoking for a certain length of time. You might even get a contribution from your parents or a friend. Put the money you save on one side and buy small items that you like with your savings.
8. When you feel like a cigarette, make up your mind to wait three minutes before smoking. By the time three minutes has passed you will often find that the craving has passed.
9. Check the cigarettes that you smoke for the tars and nicotine that they contain and buy a brand that has lower concentrations of these substances.
10. Ask yourself, "Do I need this cigarette or am I smoking reflexively, without thinking about it?"
11. Smoke only half of the cigarette, and throw the rest away.
12. Tell your friends that you are going to quit. Make sure you mean it. Make it difficult for yourself to back down on your word.
13. Try to help someone else quit smoking; it will help to keep your own resolve firm.
14. Get rid of the ash trays; put them to other uses so that you cannot stub out a cigarette in them.

continued . . .

15. Start an exercise programme and take pride in your fitness and your improved breathing capacity. As you start to enjoy exercise again, you will want to avoid smoking so that you can keep up with your friends. Try jogging, and join a club or the "Y".
16. Keep your hands busy - put them in your pockets, play a game, read a book.
17. Try to notice the times or occasions when you most frequently reach for a cigarette. Plan to avoid these situations or plan some other activity to keep your mind off the craving.

SOME HELPFUL THINGS TO OFFSET WITHDRAWAL SYMPTOMS

1. Eat well-balanced meals. Review the four food groups.
2. Drink plenty of water, milk, or fruit juice.
3. Avoid very sweet foods and drinks.
4. Enjoy fruits or raw vegetables as snacks.
5. Get plenty of exercise and do outside activities.
6. Try to relax. Take deep breaths. Consciously let yourself go limp. Start with your toes, relaxing the muscles one by one until your whole body is relaxed.
7. Take up a new interest or hobby - a craft, painting, music, sport - something to distract you. Write to friends that you met at camp or on holiday. Be creative.

Selected Readings

1. Arehart-Trieckel, Joan, ed., "Smoking is Dangerous to Your Spouse," *Science News* (January 24, 1981).
2. Avery, M. E. *et al.*, "The Lung of the Newborn Infant," *Scientific American* (April 1973).
3. Brecher, Ruth and Edward Brecher, "Breathing," The American Lung Association, (1975).
4. Collegiate Minicourse Program. B.S.C.S., "Energy in Life," (Philadelphia, W. B. Saunders, 1976).
5. Hock, Raymond J., "The Physiology of High Altitude," *Scientific American* (February 1970).
6. Lung Association. Pamphlets available from Provincial Associations and Christmas Seal Societies.
7. Naeye, Richard, "Sudden Infant Death," *Scientific American* (April 1980).
8. Oregon Tuberculosis and Health Assn., Oregon Thoracic Society, "Emphysema and Chronic Bronchitis," (1966). 1020 S.W. Taylor St., Portland, Oregon, 97205.
9. Perutz, M. F., "Hemoglobin Structure and Respiratory Transport," *Scientific American* (December 1978).
10. Western Education Development Group, Canadian Cancer Society, "Wild Cells," (1979).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "The Lungs and the Respiratory System." 17 min col., EBE
2. "Respiration in Man." 26 min col., EBE
3. "A Fight for Breath: Emphysema." 12 min col., NFB
4. "Let's Discuss Smoking." 17 min col., NFB
5. "Smokers' Lungs." 19 min col., NFB
6. "Choking: To Save a Life." 12 min col., EBE
7. "The Feminine Mistake." 25 min col., Pyramid Films (Lung Association)

Unit VII

How the Body Obtains Energy and Material for Growth

Chapter 13

The Digestive System

Chapter Focus

Food provides energy and building materials for the body. Before these materials can be used by the body, they must be broken down into molecules small enough to pass through the walls of the digestive tract and enter the capillaries of the circulatory system for distribution to all parts of the body. The digestive system consists of many structures and their secretions that break down food. Other structures facilitate the absorption process. The student must be reminded that breakdown of food is only the first step, and that until the breakdown has reached a stage where food particles are of small molecular size, the nutrients remain in the digestive tract. Only small molecules can pass through cell membranes to enter the blood vessels.

Objectives

After studying this chapter, a student should be able to

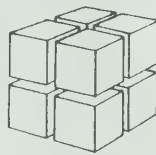
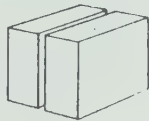
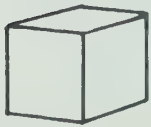
- define the function of the digestive system
- differentiate between physical and chemical digestion
- describe the structures and functions of the teeth
- describe the structure and functions of the tongue
- identify the salivary glands and list the functions of saliva
- label a diagram of the digestive system
- describe the structure and function of each of the following organs of the digestive system: esophagus, stomach, liver, pancreas, small intestine, large intestine, and rectum
- state the function of sphincter muscles
- identify the secretions of the stomach, liver, and pancreas, and list their general functions
- state how alcohol affects the body and how its effects may be measured
- explain the functions of insulin in the body
- describe the structures that enable nutrients to be absorbed
- explain the functions of the colon
- know disorders of the digestive tract: ulcers, peritonitis, appendicitis, diabetes mellitus, and hepatitis

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
The Process of Digestion	*	
Digestion in the Mouth	*	
The Teeth	*	
The Tongue		*
The Salivary Glands	*	
Other Structures in the Mouth		*
Swallowing		*
The Esophagus	*	
The Stomach	*	
Secretions of the Stomach	*	
The Small Intestine	*	
The Liver	*	
The Pancreas	*	
Absorption of Nutrients	*	
Caecum and Appendix		*
The Large Intestine	*	
The Rectum	*	

Teaching Suggestions

The students must understand the concept of the relationship between volume and surface area to appreciate that food must be broken down into small pieces for digestion. It may help to draw a cube on the chalkboard, then ask how many 1 cm faces it has. What is the cube's volume? Then, by drawing successive lines to halve the cube and its divisions, show that the number of surfaces where enzymes can act constantly increases, while the volume remains the same.



The third cube has the same volume but 6 more 1 cm² surfaces.

Students find it quite difficult to verbalize what they do when they swallow. It is an action that they have repeated many times a day for many years, but it has become automatic. Try to get the students to imagine something on their tongues and then go through the process of what they think happens before swallowing. Pass out some cookies and then ask the students to describe the actions that take place in the mouth. The ability to express actions clearly and concisely is a valuable skill and should be part of every course.

If students find the idea of peristalsis difficult, a thin rubber tube and a small marble or ballbearing may help. Place the round object a short distance into the tube beforehand, and then ask the students to work it along the tube. The squeezing or stretching action made by the students is similar to the muscle contractions of longitudinal and circular muscles. Ask the students to suggest other ways to make the action easier (oil to lubricate the tube - saliva; size of particles - chewing).

The action of sphincter muscles, controlling the entrance or exit of material into an organ or moving material from one part of a tube to another, comes up many times (capillary sphincters in the skin, bladder and defecation control, etc.). This is a good time to get the idea across. The circular ring of muscles seal off the tube entering the stomach and the exit into the duodenum.

The students all have experienced the movements made by the stomach and the sounds that they produce. They can readily understand that if the stomach walls contract to aid in the mixing, the contraction would push food out into the tubes at either end of the stomach. Therefore, a gate or control is needed at either end of the organ. These are the sphincter muscles.

Villi are often a mystery to students. Their purpose and structure can often be demonstrated simply by using a plastic or rubber glove. They can see that the area at the base of the "finger" is small and that the extension of the finger adds greatly to the surface area for more efficient absorption. Extend this idea to thousands of these all pointing into the tube around the inside of the small intestine and each again covered by microvilli, and the absorption capacity of the tract is understood more easily.

Alcohol, and its use by students, is often discussed by the Physical Education teacher during health classes. However, teachers in the Physical Education Department rarely have access to experimental apparatus and often concentrate on peer pressures and social factors. Science teachers can reinforce ideas, or supplement the work of other departments, with experiments. The "Interest Box" on page 312-13 can be most useful in getting discussion started. The "Case Study" on page 162 will also help. A realistic understanding of the effects of alcohol on the body is accepted well by students, especially if the teacher avoids criticizing or moralizing. In many cases, students will discuss their actions and experiences more freely in this environment than in a situation of condemnation of all drugs and alcohol.

This may be a good place to introduce a dissection of a mammal that is suitable for the study of the gross anatomy of the major organs and systems. The teacher may also wish to use microscopic slides of sections of the stomach wall, the small intestine, or other digestive organs. The 16 mm film, "The Digestive System", is excellent. "How a Hamburger Turns into You" is also full of excellent material, although it is aimed at a slightly less advanced level.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 321)

- | | |
|----------------|---------------------|
| 1. pancreas | 6. dentin |
| 2. bile | 7. sphincter |
| 3. pepsin | 8. mesentery |
| 4. peristalsis | 9. epiglottis |
| 5. villi | 10. large intestine |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 321)

1. Physical digestion involves the breakdown of food into smaller pieces

mainly by the biting, grinding, and chewing action of the teeth. Chemical digestion requires enzymes that split the large molecules of food into smaller molecules small enough to pass through the membranes of cells and capillaries.

2. Incisors: light chisel-shaped teeth for biting or cutting food
Canines: pointed teeth that help to tear and shred food
Molars: teeth that are square and flatter than the other teeth; used for grinding and chewing food
3. Digestion is the breaking down of food substances into molecules small enough to enter the capillaries and cells. Absorption is the process by which small molecules pass out of the digestive tract and into the capillaries and from the capillaries into the cells of the body, where they can be used. Fats are absorbed through the lacteals.
4. Fibre is used in the diet to hold water in the digestive tract. It prevents fecal waste from becoming too dry and hard, and helps to prevent a number of digestive disorders.
5. The pH of the stomach is about pH 2 and is produced by hydrochloric acid formed by the glands of the stomach. The duodenum is pH 7-8, and the stomach is neutralized by alkaline secretions from the pancreas.
6. Starch: digested in the mouth by amylase
Proteins: digested in the stomach by the action of hydrochloric acids and pepsin
Fats, sugars, and proteins: digested in the small intestine by the action of digestive enzymes, secreted by the pancreas and working in the small intestine
7. Sphincters are rings of muscles that are found around many vessels and tubes in the body. They act like a draw-string purse to close off the tube and prevent the passage of materials along the tube.
8. Ulcers form when a part of the digestive tract wall is eroded by the acids and digestive juices of the system. The protective mucin is unable to prevent irritation by the digestive juices, and they start to digest a part of the wall itself.
9. The colon or large intestine allows the reabsorption of water and the drying of the feces. Some inorganic salts are absorbed here and there is usually a large number of nonpathogenic bacteria and micro-organisms present that help to produce some vitamins from the undigested foods.
10. Hepatitis is an inflammation of the liver. Infectious hepatitis symptoms are tiredness, poor appetite, abdominal pains, fever, and an enlarged or tender liver. The skin appears jaundiced. Hepatitis is spread by contact with other infected persons, often in overcrowded conditions where poor sanitation and living conditions are found.

Serum hepatitis is transmitted by entry into the blood system, usually by the use of unsterilized needles, injections, or blood transfusions. The symptoms are similar to those of infectious hepatitis.

Text Activities

ACTIVITY 1: THE SALIVARY DIGESTION OF STARCH (TEXT, PAGE 322)

PART I

MATERIALS

25-mL test tubes, test tube rack, 3% starch solution, Benedict's solution, iodine solution, wax-marking pencils, water bath

ACTIVITY OBJECTIVES

1. to show that saliva contains an enzyme that starts chemical digestion in the mouth
2. to show that salivary amylase breaks down starch to sugars
3. to demonstrate that the presence of starch may be detected with iodine, which turns from brown to black (or deep purple) in the presence of starch. (Most sugars can be identified by the use of Benedict's solution, which turns from blue to green, yellow, or brick red after heating. Lower concentrations of sugar are indicated by green or yellow and stronger concentrations by brick red.)
4. to show that high temperatures destroy the effectiveness of enzymes

ANSWERS TO QUESTIONS

1. Starch test: iodine solution turns from brown to black in the presence of starch.
Sugar test: Benedict's solution turns from blue to orange or brick red in the presence of sugar.
2. Test tubes A and B are controls, used for comparison of changes that take place.
3. Iodine solution indicates the presence of the initial substance. Benedict's solution indicates the presence of the final substance, sugar. As one substance decreases, the other should increase.
4. Saliva contains an enzyme that breaks starch down to sugar.
5. High temperatures destroy the effectiveness of the enzyme.

PART II

What effect does the pH of a solution have on the action of a digestive enzyme? (text, page 323)

MATERIALS

HCl solutions of pH 3, 6, 8 and 10, 25-mL test tubes, test tube rack, spot plates, iodine solution, 3% starch solution, 1% diastase solution

ACTIVITY OBJECTIVES

1. to show that enzymes are affected by high temperatures and pH
2. to show that enzymes work best between fairly narrow limits of pH
3. to demonstrate that extremes of pH inhibit or destroy enzymes

PREPARATION TIPS

The need for clean glassware must be stressed in this experiment as the pH difference between the samples is quite small. The teacher will find that Hydrion paper or a similar multicoloured test strip will save time in the preparation of the different pH values. A piece of white paper under the spot plate will aid the students in seeing whether or not digestion has taken place.

ANSWERS TO QUESTIONS

1. Results will vary, but will be close to neutral.
2. The pH of the duodenum varies between 5 and 8. Some enzymes require a pH of between 5 and 6; others require a pH of between 7 and 8. Mouths may vary from one student to another, but will not differ greatly; the mouth is slightly acid.
3. Graph.
4. Results may vary due to settling of the starch granules in the sample, or due to variations in dropper size and imprecise measurements. Teachers should discuss experimental errors, or require students to do so, after all experiments.

ACTIVITY 2: THE ACTION OF LIPASE ON FATS (TEXT, PAGE 324)

MATERIALS

fresh whole milk, pancreatin or lipase, 25-mL test tubes, phenolphthalein solution, detergent, 1 mol sodium carbonate solution, water bath, hotplate

ACTIVITY OBJECTIVES

1. to show that milk contains fats
2. to observe that fats can be emulsified by detergents
3. to determine that pancreatin breaks down fats into fatty acids and glycerol
4. to demonstrate that fatty acids can be tested with phenolphthalein
5. to demonstrate that digestion takes place more actively at body temperature

ANSWERS TO QUESTIONS

1. To emulsify the fats present.
2. Answers will vary. Close to neutral.
3. Neutralize any acids present.
4. Colour change indicates the presence of acids (fatty acids).

5. Temperature is close to body temperature.
6. Final products are glycerol and fatty acids.

ACTIVITY 3: PROTEIN DIGESTION (TEXT, PAGE 325)

ACTIVITY OBJECTIVES

1. to show that the pH of the digestive tract differs from one part to another
2. to demonstrate that an acid condition is necessary in the stomach to activate pepsinogen for the digestion of protein
3. to observe that the acid must be neutralized before enzymes in the duodenum can work effectively

PREPARATION TIPS

Although pieces of egg white that are consistent in size are useful, small variations do not affect the validity of the experiment. The end result will show that digestion has occurred in some tubes but not in others.

Sometimes more than 24 h are needed to effect complete digestion of the egg white.

ANSWERS TO QUESTIONS

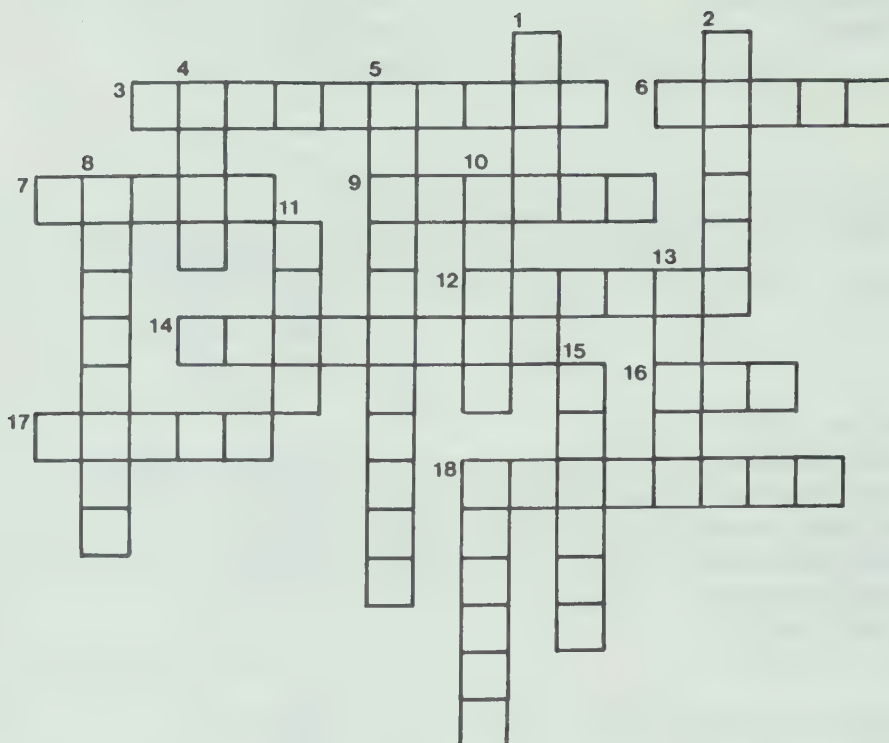
1. Egg white provides a suitable source of protein.
2. Pepsin acts most effectively in the stronger acid range. Results will vary, but should be approximately pH 2.
3. Pancreatin is most effective in a neutral or weak base solution.
4. Students should recognize that the pH of the stomach is strongly acid and the pH of the duodenum is neutral to weak base.
5. Controls enable comparisons to be made. In test tubes 1 and 4, no pH variables are used. Students may supply other possible controls such as the use of water, etc.

Self-test: Select the best answer

1. The salivary glands produce amylase which digests
 - a) sugars
 - b) starch
 - c) proteins
 - d) fats
2. The molars are used for
 - a) grinding
 - b) biting
 - c) holding
 - d) tearing
3. Peristalsis involves the
 - a) digestion of proteins
 - b) production of saliva
 - c) movement of food along the digestive tract by muscular contractions
 - d) membranes holding the intestines in place
4. Bile is responsible for the
 - a) digestion of proteins
 - b) digestion of starches
 - c) breakdown of fats into smaller droplets
 - d) chemical digestion of fats
5. Which of the following is not produced by the stomach?
 - a) mucin
 - b) HCl
 - c) pepsinogen
 - d) amylase
6. The appendix is directly attached to the
 - a) colon
 - b) ileum
 - c) duodenum
 - d) caecum
7. The normal end products of protein digestion are
 - a) amino acids
 - b) monosaccharides
 - c) glycerol
 - d) fatty acids
8. The bile duct leads into the
 - a) ileum
 - b) stomach
 - c) jejunum
 - d) duodenum
9. The largest gland in the body is the
 - a) pancreas
 - b) liver
 - c) stomach
 - d) parotid gland
10. The villi
 - a) absorb fats
 - b) increase surface area in the small intestine for more efficient absorption
 - c) are fingerlike projections
 - d) contain blood vessels and lacteals
 - e) All of these answers are correct.

B d
a a
c d
d b
e c

Crossword



DOWN

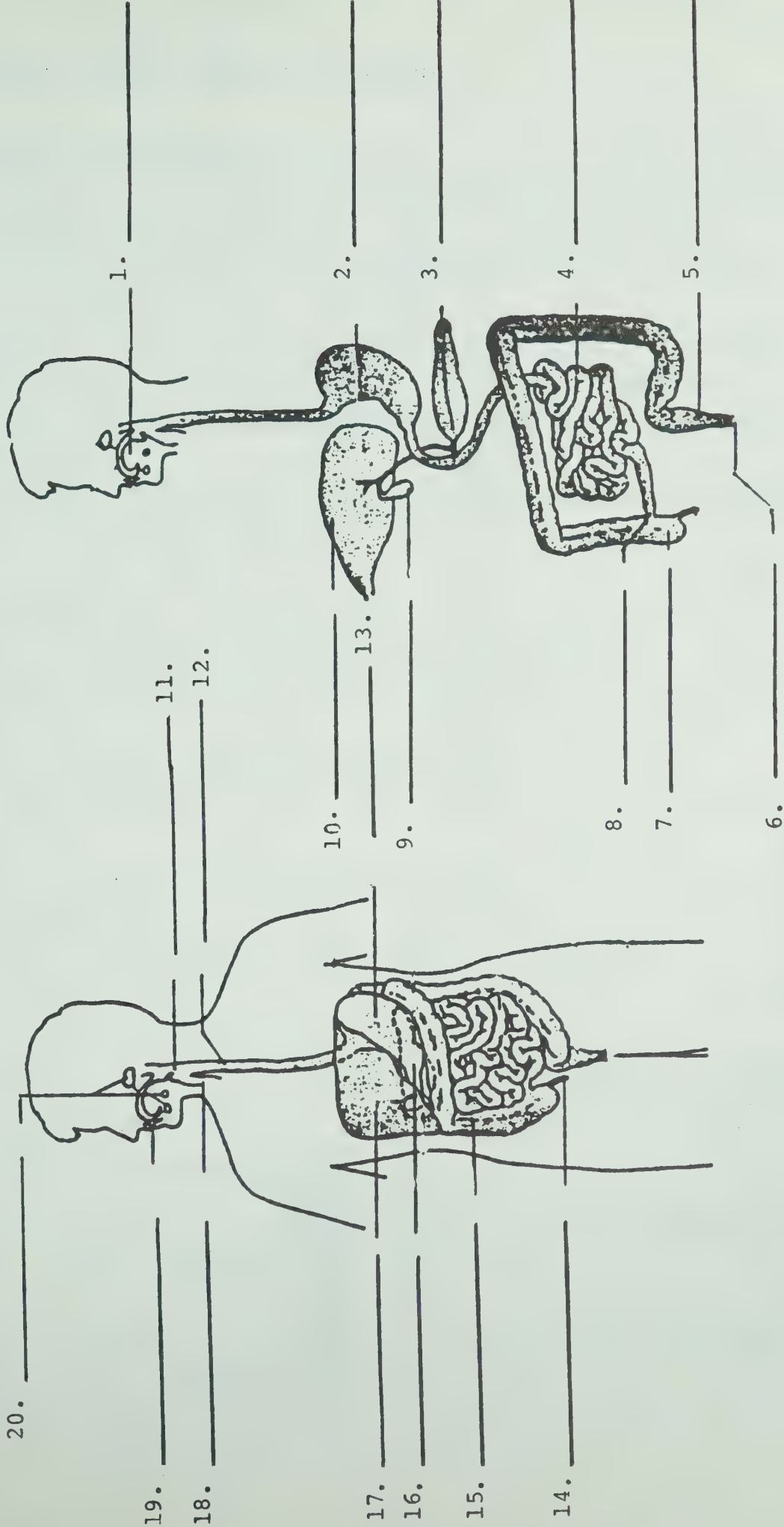
1. base of a tooth
2. three layers of this tissue are found in the walls of the stomach
4. produced by the liver
5. rhythmic movements of the digestive tract walls
8. teeth used for cutting
10. large intestine
11. bladder holding bile
13. formed when starch is digested
15. lymph tissue at back of mouth
18. secreted by the stomach

ACROSS

3. takes place after digestion
6. folds on the inside of the stomach
7. finger-like structures for absorption in the small intestine
9. last part of the digestive tract
12. enzyme that digests fat
14. substance dissolved in water
16. digestive tract
17. where salivary enzymes digest starch
18. gland that produces many enzymes

The Human Digestive System

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. d) |
| 2. a) | 7. a) |
| 3. c) | 8. d) |
| 4. c) | 9. b) |
| 5. d) | 10. e) |

ANSWERS TO CROSSWORD

DOWN

1. root
2. muscle
4. bile
5. peristalsis
8. incisors
10. colon
11. gall
13. sugar
15. tonsil
18. pepsin

ACROSS

3. absorption
6. rugae
7. villi
9. rectum
12. lipase
14. solution
16. gut
17. mouth
18. pancreas

LABEL ANSWERS TO "HUMAN DIGESTIVE SYSTEM"
(Taken from Figure 13.9, text page 308)

- | | |
|-------------------------|---------------------|
| 1. tongue | 11. pharynx |
| 2. stomach | 12. esophagus |
| 3. pancreas | 13. stomach |
| 4. small intestine | 14. appendix |
| 5. rectum | 15. large intestine |
| 6. anus | 16. pancreas |
| 7. caecum | 17. liver |
| 8. ileocaecal sphincter | 18. trachea |
| 9. gall bladder | 19. mouth |
| 10. liver | 20. salivary glands |

Selected Readings

1. Davenport, W. H., "Why the Stomach Does Not Digest Itself," *Scientific American* (January 1972).
2. Guyton, Arthur, "Function of the Human Body," 4th ed. (Philadelphia: W. B. Saunders, 1977).
3. Kappas, A. and A. P. Alvares, "How the Liver Metabolizes Foreign Substances," *Scientific American* (June 1975).
4. Lieber, Charles S., "The Metabolism of Alcohol," *Scientific American* (March 1976).
5. Scrimshaw, N. S. and U. R. Young, "The Requirements of Human Nutrition," *Scientific American* (September 1976).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "The Digestive System." 17 min col., EBE
2. "How a Hamburger Turns into You." col., Viking Film Ltd.

FILMSTRIPS

1. "The Digestive System." With cassette. Wards Solo Learn, Arbor Scientific, Ont.
2. "The Digestive System." Visual Education Centre, Canada Ltd.

SUPER-8 FILMLOOPS

From (Wards) Arbor Scientific, Ont.

1. "Pepsin."
2. "Ptyalin."
3. "Protein Digestion."
4. "Effect of pH."
5. "Effect of Temperature."

Chapter 14

Nutrition

Chapter Focus

This chapter and the one following it focus on how to make wise decisions about what to eat and why this is important. At the same time, it is important to dispel many of the misconceptions held by students. Food fads and fallacies, often reinforced by poorly researched magazine articles, are prevalent in every class. Perhaps more than in any other section of the course, there is a need to "unlearn" inaccurate knowledge about foods.

This chapter provides a basis for the material in the next chapter, but in both chapters there must be an attempt to change attitudes and promote an appreciation of the need for a balanced diet. Knowledge, without the understandings that can promote additudinal change, is of no lasting value. Students will have been exposed to many years of diet training at the family table, some good and some poor. The students have now reached an age when they are controlling much of what they eat, and need a basis for making wise decisions.

Objectives

After studying this chapter, a student should be able to

- define the term "diet"
- list the major components of food
- state the chemical components of carbohydrates, fats, and proteins that are the end products of digestion
- define "kilojoule" and give examples to demonstrate the approximate values of this energy unit in common foods
- list examples of food sources that are rich in carbohydrates, fats, and proteins
- demonstrate that he or she recognizes the differences between essential amino acids and other amino acids
- list examples of the body's need for water
- define what a vitamin is and list the water and fat soluble vitamins
- give examples of foods that are rich in vitamins
- give examples of minerals required by the body and their values to the body
- give examples of foods that are good sources of specific minerals
- explain the functions of fibre in the diet and give examples of foods rich in fibre

Topic Priorities

TOPIC	of Major Importance	of Minor Importance
What Determines a Diet	*	
The Major Food Substances	*	
Carbohydrates	*	
Fats	*	
Proteins	*	
Water	*	
Vitamins	*	
Minerals	*	
Fibre in the Diet	*	

Teaching Suggestions

The material in this chapter is straightforward. The major teaching decision is the depth to which the chemical content is to be studied. This will be largely determined by the level of student ability.

It is important to make the chemical aspects of the chapter relate to digestion. This can be done by showing the components that each food type is broken into and by promoting an understanding that the molecules are required to be a small size in order to be absorbed into the blood stream for distribution to body cells.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 344)

- | | |
|----------------|-----------------|
| 1. fibre | 6. protein |
| 2. glucose | 7. vitamin K |
| 3. glycogen | 8. calcium |
| 4. insulin | 9. carbohydrate |
| 5. cholesterol | 10. hemoglobin |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 344)

- Carbohydrates provide the major source of energy for the body. Fats also provide energy for the body. Proteins provide essential building materials for growth and repair of body tissues, as well as energy.
- Carbohydrates are found chiefly in plant foods that are usually grown quickly and cheaply. These foods thus form a large part of our diet.
- Cholesterol is a major part of the fatty deposits that form inside blood vessels, reducing the size of the vessels and increasing blood pressure. It is considered by many to have an important influence on heart problems.

4. Essential amino acids are those that the body cannot make for itself from other sources. These essential amino acids must be supplied directly in the diet. If any of these essential amino acids are missing, a special protein needed by the body may not be formed.
5. Water is essential for life. It is needed to dissolve food, and dilute wastes and toxins in the blood. It bathes cells and acts as a medium carrying substances around in the body. Water helps to cool the body and maintain many homeostatic balances within the body.
6. Vitamins may be destroyed or lose their effectiveness in the following ways (depending on the particular type of vitamin):
 - a) heating or overcooking,
 - b) present in solutions too basic or acidic
 - c) exposure to bright light,
 - d) contact with oxygen.Vitamins A, D, E, and K must be present with fats in order to be absorbed.
7. Fat soluble vitamins are vitamins A, D, E, and K. Water soluble vitamins are Thiamin, Riboflavin, Niacin, and vitamins B and C. Food substance answers will vary widely. See *Canada Food Guide* booklets, or chart on pages 340 and 341 of the text.
8. Iron: liver, heart, meats, green leafy vegetables, cereals, nuts
Calcium: milk, cheese, cereals, beans, hard water
Iodine: iodized salt, sea foods
9. Whole wheat breads contain more fibre than white bread. While white bread has many vitamins added to replace those lost during processing, many of the amino acids that are lost when the grain is stripped away and bleached are not replaceable.
10. Fibre is important in the diet to hold water and prevent the digested foods from becoming tightly packed together; it thus helps prevent constipation. Fibre helps in bile salt metabolism. Poor fibre diets are believed to be a partial cause of gallstones and some digestive and bowel problems.

Text Activities

ACTIVITY 1: SUGARS (TEXT, PAGE 345)

MATERIALS

Benedict's solution, 25-mL test tubes, solutions of glucose, corn syrup, brown sugar, sucrose, and starch (about 1% solutions by weight are suitable), hot plates with water baths, dilute hydrochloric acid

ACTIVITY OBJECTIVES

1. to show that Benedict's solution is a positive test for sugars
2. to show that when heated in a water bath in the presence of a sugar, the Benedict's solution turns from blue to green, yellow, orange and, finally, to brick red
3. to demonstrate that the final colour reached will depend upon the concentration of sugar in the solution

PREPARATION TIPS

The concentrations of solutions are not too important. If some are weak and some are strong, the students may start to ask questions about why the Benedict's solution does not always turn to the same colour, and its value as a quantitative as well as qualitative test may be discussed. Some teachers may not wish to get into reasons behind the differences between reducing and non-reducing sugars. If this is your decision, avoid using sucrose, and the other results should be consistent.

ANSWERS TO QUESTIONS

1. Benedict's solution turns from blue to brick red in the presence of sugar.
2. The sequence of colours indicates the quantity of sugar present, green indicates very little sugar and orange shows that much more sugar is present.
3. Answers will vary. Basically, a series of test tubes may be set up with known amounts of sugar present (0.5%, 1.0%, 1.5%, etc.). Any unknown solution can then be compared to these by colour.
4. Starch breaks down into simple sugars by the action of acid and boiling.
5. Starches are composed of long, branching chains of sugar molecules. Sugars are simpler molecules composed of either single units (monosaccharides) or double sugar units (disaccharides).

ACTIVITY 2: CARBOHYDRATES (TEXT, PAGE 346)

MATERIALS

spot plates, iodine solution, starch solution (10% by weight), potato, apple, carrot, sugar solution (1% by weight)

ACTIVITY OBJECTIVES

1. to show that many common foods contain starch
2. to recognize that starch can be identified by the iodine test
3. to show that starch appears as small insoluble granules

ANSWERS TO QUESTIONS

1. Starch may be identified by testing it with iodine, which changes from brown to black or deep purple in the presence of starch.
2. Starch is usually insoluble and can be seen as small oval granules. These are distinguished more easily under the microscope.
3. Most fruits, grains, bread, and root vegetables contain starch.

ACTIVITY 3: THE IDENTIFICATION OF FATS AND OILS (TEXT, PAGE 347)

MATERIALS

25-mL test tubes, Sudan IV, brown paper, Bromothymol blue indicator, olive oil, vegetable oil, mineral oil, margarine, cream, soap detergent

ACTIVITY OBJECTIVES

1. to show that oil does not mix with water
2. to demonstrate that oil is less dense than water and so it rises to the surface
3. to show that oil can be emulsified or split into smaller droplets by detergents
4. to show that oils can be identified because it takes up Sudan IV stain
5. to demonstrate that fats or oils will turn brown paper translucent

ACTIVITY 4: IDENTIFICATION OF PROTEINS (TEXT, PAGE 347)

MATERIALS

egg white mixed with water about 50/50, milk, egg shell, gelatin, meat emulsion, Millon's reagent, Biuret reagent, 25-mL test tubes, water bath, hotplate

ACTIVITY OBJECTIVES

1. to show that some foods contain proteins
2. to demonstrate that proteins can be tested with either Millon's or Biuret reagent
3. to recognize that Millon's reagent turns from clear to a faint pink colour and often produces a pink amalgum
4. to show that Biuret reagent turns from blue to faint purple in the presence of a protein

PREPARATION TIPS

Any meat scraps placed in a blender with a little water will provide a suitable meat emulsion. After blending, strain through cheesecloth.

ANSWERS TO QUESTIONS

1. See above.
2. It is important to encourage students to think in terms of controls.
3. Answers will vary.

NOTE: As protein tests indicate the presence of certain amino acids, it is possible to get conflicting results. If one test is positive and the other negative, the negative result should be ignored as the amino acids that it tests may not be present in sufficient quantities in that particular sample.

Additional Activities

ACTIVITY 14.A: EXAMINATION OF STARCH GRANULES

MATERIALS

See Activity 2, page 346, in text.

METHOD

1. Take the stained piece of potato or apple that you have tested and, with a scalpel or razor blade, slice the thinnest wedge you can. As the sections you have used are many cells thick, the granules will be piled on top of one another. At the thin edge of the wedge you should have a small area where the tissue is only one or two cells thick. Place the tissue on a glass slide and examine it under the low power of the microscope.
2. Record your observations and draw what you see.
3. At one end of a glass slide, place a small drop of starch solution and add a drop of iodine. At the other end of the slide, add a drop of glucose solution and also add iodine. Cover the solutions with coverslips and examine under the microscope.

QUESTIONS

1. State in what form starch is found, noting any consistencies in size or shape of the materials you have examined.
2. What relationship exists between monosaccharides and starch? Does sugar show up under the microscope? Is it in solution? Does it respond when iodine is added? Is it a carbohydrate?
3. What happens to starch when it enters the body?

ACTIVITY OBJECTIVES

1. to improve microscope techniques
2. to improve the skills of observation and drawing from the microscope
3. to recognize insoluble starch granules
4. to determine the number of starch granules that are present in a single cell

ANSWERS TO QUESTIONS

1. Starch granules appear as small oval bodies which vary slightly in size. They are dense and stained black by iodine.
2. Monosaccharides are single sugars composed of one molecule. Starch is a chain of these single molecules, joined together by chemical bonds. Sugar does not show up under the microscope when in solution. It does not respond to staining by iodine. Sugar is a member of the carbohydrate group.
3. Starch is digested in the mouth by amylase and reduced to double sugars (disaccharides). It is further digested and split into monosaccharides in the digestive tract before it is absorbed into the blood stream.

ACTIVITY 14.B: DETERMINE THE RELATIVE QUANTITIES OF VITAMIN C PRESENT IN VARIOUS FOODS

Vitamin C (ascorbic acid) is present in most citrus fruits, tomatoes, and leafy green vegetables. One of its chemical properties is that it is a reducing agent; that is, it removes oxygen from, or adds oxygen to, other chemicals. Indophenol is a blue dye that is bleached by ascorbic acid because of the reducing properties of vitamin C.

MATERIALS

apple juice, orange juice, or drinks with vitamin C added, rose hip extract, 0.125% ascorbic acid, distilled water, 0.003 mol/L indophenol solution, test tubes and rack, water bath and hotplate, eyedroppers

METHOD

1. Add 10 drops of indophenol to a test tube. Add the ascorbic acid solution drop by drop and gently shake the tube after each drop. Count the number of drops required to turn the indophenol colourless or pale pink. Record the number of drops required. Make sure that the test tubes are dry and that you count the drops accurately.
2. Add 10 drops of indophenol to a clean, dry test tube and then add, drop by drop, one of the samples of fruit juice to be tested. Count and record the number of drops required to turn it pale pink or colourless.
3. Repeat using the other samples. Record your results.
4. Use a sample of distilled water as a control.
5. Take a fresh sample of one of the fruit juices, boil it for about 5 min, and then test it as before. Record your results.
6. Leave out on the bench overnight a sample of one of the juices you have tested. Test it after 24 h and compare the results with the fresh juice.

QUESTIONS

1. If a sample of juice A requires 8 drops to bleach it and a sample of juice B takes 12 drops, which has the stronger concentration of vitamin C?
2. What effect does exposure to air have on vitamin C? Explain your observations.
3. What is the effect of boiling vitamin C? If vegetables contain vitamin C, what happens when they are cooked? What can be done to minimize this problem?
4. Which of the samples tested by you had the most vitamin C? Did the label

continued . . .

HANDOUT

indicate the amount present? According to your experimental results, do you think that the labels are accurate indications of the amount present?

5. Was there any relationship between the price of the juice and the amount of vitamin C present? Could you determine which juice was a "good buy" for vitamin C content?

ACTIVITY OBJECTIVES

1. to show that indophenol can be used to determine the presence of vitamin C
2. to show that indophenol turns colourless in the presence of vitamin C
3. to demonstrate that vitamin C is quickly lost on exposure to the air
4. to demonstrate that vitamin C is destroyed by boiling or high temperatures

ANSWERS TO QUESTIONS

1. Sample A will have the stronger concentration; it takes fewer drops of juice to change the indicator.
2. Vitamin C is quickly lost on exposure to air. A reaction occurs between oxygen in the air and vitamin C which neutralizes the acid.
3. Vitamin C is destroyed by boiling. Prolonged boiling or overcooking destroys several vitamins including vitamin C. Vegetables should be cooked lightly, and served while still crisp.

ACTIVITY 14.C: EXAMINATION AND ANALYSIS OF FOOD LABELS**METHOD**

1. Make a collection of food labels that list the ingredients contained in the product. Include some of the wrapped products that are dispensed from coin machines or available in the school cafeteria. Take some products from the kitchen shelf such as soups, pudding cups, or cake mixes.
2. Read the labels carefully, then list the ingredients present in a suitable table.

Product	Starch	Sugar	Fat/Oil	Protein	Vitamins/Minerals	Additives

Look up any terms such as dehydrated, hydrogenated, or hydrolyzed, etc., and give brief definitions of each.

3. Examine the advertising label on the product. What "appeals" have been made so that you will want to buy the product (colour printing, names, give-aways, claims, etc.)?
4. Rate the products you have examined for
 - a) food value
 - b) appeal (flavour, eye appeal, texture, etc.)
5. Select several items from this list:
 - a) apple
 - b) orange
 - c) peanuts
 - d) raisins
 - e) whole wheat cookiesRate them on food value and appeal. Use food tables to discover what nutrients are present. Compare the cost of each of these items with the cost of the packaged snack foods that you examined earlier.
6. Make a brief summary statement about the foods, packages, and contents of the items you have studied.

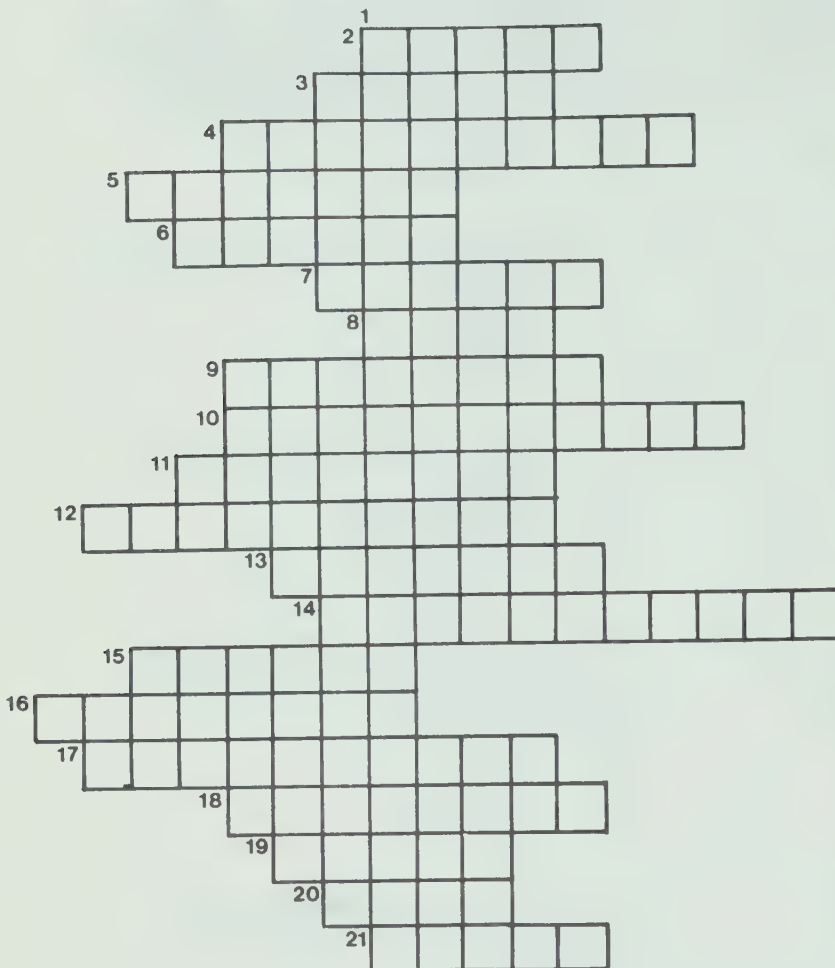
PREPARATION TIPS

This activity can be assigned as a home project. It provides a useful consumer study and helps students become aware of the food value of the products they are buying. It helps them assess their buying habits in terms of value for money and the influence of advertising.

Self-test: Select the best answer

1. An example of a monosaccharide is
 - a) glucose
 - b) sucrose
 - c) maltose
 - d) glycogen
2. Which of the following molecules are formed from chains of amino acids?
 - a) carbohydrates
 - b) fats
 - c) proteins
 - d) fibre
3. Which of the following is the richest source of energy?
 - a) carbohydrates
 - b) proteins
 - c) fats
 - d) sugars
4. Which of the following is composed of inorganic elements?
 - a) vitamins
 - b) proteins
 - c) fats
 - d) minerals
5. Which of the following provides the body with materials for cell growth?
 - a) minerals
 - b) proteins
 - c) fats
 - d) carbohydrates
6. Molecules with double bonds and less than the maximum number of hydrogen atoms present are called
 - a) saturated fatty acids
 - b) unsaturated fatty acids
 - c) fats
 - d) vegetable oils
7. Some vitamins may be destroyed by
 - a) oxidation
 - b) light
 - c) cooking
 - d) All of these.
8. Bran is an excellent source of
 - a) fibre
 - b) carbohydrate
 - c) calories
 - d) vegetable oils
9. What mineral is often lacking in people who suffer from some types of anemia?
 - a) calcium
 - b) iron
 - c) phosphorus
 - d) iodine
10. Which of the following foods provide the best source of calcium?
 - a) fruits
 - b) meats
 - c) cereals
 - d) milk

Crossword



DOWN

1. two types of food categories that provide energy (_____ and _____)

ACROSS

2. this is not digested, but helps retain water
3. many of these are minerals; one of these may be found on the table
4. part of fat molecules (2 words)
5. a monosaccharide
6. grain
7. biological catalyst; helps in digestion
8. the pattern of daily food intake
9. a stored form of sugar
10. type of fat that affects deposits of cholesterol
11. unit of food energy
12. important source of many vitamins
13. helps build new tissues
14. fatty substance that causes some types of heart problems
15. this is produced when sugar is oxidized
16. what happens to food after it has been digested
17. meat-free diet
18. an important part of the diet for maintaining good health
19. the B vitamins dissolve in this
20. good source of protein
21. a problem substance in "junk" foods

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. a) | 6. b) |
| 2. c) | 7. d) |
| 3. c) | 8. a) |
| 4. d) | 9. b) |
| 5. b) | 10. d) |

ANSWERS TO CROSSWORD

DOWN

1. fats and carbohydrates

ACROSS

2. fibre
3. salts
4. fatty acids
5. glucose
6. cereal
7. enzyme
8. diet
9. glycogen
10. unsaturated
11. calories
12. vegetables
13. protein
14. cholesterol
15. energy
16. absorbed
17. vegetarian
18. vitamins
19. water
20. meat
21. sugar

Additional Resource Material

TABLE: COMPARATIVE NUTRIENT VALUES FOR SOME COMMON BEVERAGES

	Energy	Energy	Protein	Fat	Carbohydrate	Calcium	Iron	Vitamin A	Thiamin	Riboflavin	Niacin	Vitamin C	Amount
	kJ	Cal.	g	g	g	mg	g	IU	mg	mg	mg	mg	g
Milk 3.5%	1008	240	14	14	18	432	0.2	525	0.11	0.62	0.3	3	345
Milk 2%	773	184	14	8	18	451	0.2	258	0.15	0.66	0.3	3	340
Apple Juice	756	180	tr.	-	45	22	2.0	-	0.03	0.06	0.3	120	343
Orange Juice	756	180	3	1.5	39	40	0.7	700	0.35	0.12	1.5	186	343
Tea	8	2											343
Coffee	13	3											340
Cola	609	145			37								340
Ginger Ale	483	115			29								340
Beer	630	150	1		14	18				0.11	0.12		340
Spirit	441	105											42

This is a reproduction of Table 14.3, page 337 of the text, with the Calorie units added.

Food	Energy	Protein	Fat	Carbohydrate	Calcium	Iron	Vitamin A	Thiamin	Riboflavin	Niacin	Vitamin C	Amount
	kJ	g	g	g	mg	mg*	RE**	mg	mg	NE***	mg	g
Milk 3.3% fat	660	8	9	12	306	0.1	106	.10	.42	2.3	13	257
Milk 2%	540	9	5	12	315	0.1	106	.10	.43	2.3	13	258
Apple Juice canned	530	tr	tr	32	16	1.6	-	.02	.04	0.3	93	262
Orange Juice, fresh	490	2	1	27	29	0.5	53	.23	.07	1.0	131	262
Tea	0	-	0	tr	4	0.2	-	-	.04	-	0	224
Coffee	20	tr	0	1	5	0.2	-	-	-	0.2	0	235
Cola	320	0	0	20	-	-	0	0	0	0	0	197
Ginger Ale	260	0	0	15	-	-	0	0	0	0	0	195
Beer	630	1	0	14	18	tr	-	.01	.11	2.2	-	360
Spirit	490	-	-	-	-	-	-	-	-	-	-	47

UPDATED TABLE (with different amounts) from "Nutrient Value of Some Common Foods," Health and Welfare Canada, 1982.

* Iron is now expressed in milligrams (mg) not in grams.

** Vitamin A is now expressed in retinal equivalents (RE).

*** Niacin is expressed in niacin equivalents (NE).

Selected Readings

1. Greenberg, Noel, "The Fat American," *Scientific American* (November 1980).
2. Kolata, Gina, "Obesity, A Growing Problem," *Science* (December 2, 1977).
3. Kutsky, Roman, *Handbook of Vitamins and Hormones* (New York: Van Nostrand Reinhold, 1973).
4. Mayer, Anne, *The Fiber Factor* (Emmaus, Pa.: Rodale Press, 1976).
5. Scrimshaw, N. S. and V. R. Young, "The Requirements of Human Nutrition," *Scientific American* (September 1976).
6. Scrimshaw, Nevin and Lance Taylor, "Food," *Scientific American* (September 1980).
7. Sharon, Nathan, "Carbohydrates," *Scientific American* (November 1980).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Cholesterol. Eat Your Heart Out." 13 min col., Informedia Productions
2. "To Each a Rightful Shame." 28 min col., NFB

FILMSTRIPS

1. "The Teeth and Eating." Visual Education Centre, Canada Ltd.
2. "Warning: Eating May Be Hazardous to Your Health." With cassette. Carolina Biological
3. "Introduction to Nutrition." Wards Solo Learn. Arbor Scientific, Ont.
4. "Introduction to Vitamins." Wards Solo Learn. Arbor Scientific, Ont.

Chapter 15

Diet – Knowing What and How Much to Eat

Chapter Focus

The basis of this chapter is the *Canada Food Guide*. There should be a balance maintained in a person's diet between kilojoules of energy taken into the body and kilojoules expended. The kilojoule is a difficult unit for students to visualize and any demonstrations or experiments that help students to establish a more tangible image of its quantity are useful.

The value of this section is greatly enhanced when it is directly related to the student's own diet, and most of the material in this chapter should be taught directly through analysis and evaluation of the student's own eating habits.

Objectives

After studying this chapter, the student should be able to

- identify the four food groups of the *Canada Food Guide*
- state the number of servings required for each food group and the size of portions required
- give examples of foods that represent each food group
- be familiar with methods of assessing body size
- demonstrate the value and disadvantages of the methods of assessing body size
- compute a figure that represents ideal body mass to the individual's satisfaction
- list the problems associated with excess body mass
- explain the balance required between food intake and energy expenditure
- list the value of exercise in maintaining body mass

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
A Daily Food Guide	*	
The Milk Group	*	
The Meat Group	*	
The Fruits and Vegetables Group	*	
The Bread and Cereals Group	*	
Understanding the Daily Food Guide	*	
Breakfasts and Evening Meals		*
The Assessment of Body Size	*	
Height/Mass Tables		*
Skinfold Calipers or the Skinfold Test	*	
The Problems Associated with Being Overweight	*	
Working Off the Excess - by Exercise	*	
For the Very Overweight		*
On Being Underweight		*

Teaching Suggestions

This topic is best approached by using the experiments at the end of the chapter to make the material directly applicable to each student. Have the students work through Activity 1; then have the students apply the *Canada Food Guide* to their own records. This will establish what food groups are lacking or are in excess in the students' diets. They can then recognize what changes might be made to improve their diets. This exercise is followed by Activities 2 and 3 to determine each student's present and ideal body mass.

The results of these three activities can be analysed in an assignment. After the activities, the students have the data on their diet and body mass, together with projected ideal mass. A discussion on personal eating habits, mass, and desires can now be approached more objectively. Such an assignment can be very helpful to the students who will often be very open and honest about themselves. The personal approach provides especially good motivation and is far more effective than any formal classroom teaching.

Science teachers are generally content to adopt the new SI units. However, the calorie is still firmly entrenched in most parts of Canada. It is also still commonly used by dieticians, in magazine articles, and on food products. Terms such as "empty calories" are familiar to most students and "empty kilojoules" does not as yet roll off the tongue with the same ease. "Excess body mass" rather than the well-worn "overweight", still feels uncomfortable, and teachers may find that a slavish adherence to the SI ideology is best relaxed for a time. Advanced level students tend to adapt readily to the changes, but general level students are often intimidated or even resentful of the changes. Teachers should consider this before determining their own approach.

The main objective is to help students understand their own diet and to help them modify unhealthy eating habits for better nutritional balance. If units confuse and obscure this objective, then teachers may wish to relax their

enthusiasm for metric conversion for a year or two until the rest of the world catches up. All the tables still in general use have the calorie and, if these are made available to students, they can use whatever units they find most appropriate. Many students do not have metric measuring vessels in the home and this also presents difficulties if rigid rules are set.

The Physical Education Department may be willing to co-operate with you on a fitness program in conjunction with this topic. They can also help with some appropriate fitness-testing activities. This makes a very complete and appropriate ending to the exercise.

Some students might be willing to do an inventory of the food being sold in the school cafeteria. They may be able to determine how much of each kind of food is sold according to food groups, and what balance of the food groups is purchased by specific groups of students. Their efforts could improve general awareness of good nutrition, influencing others to buy more balanced meals.

Questions for Review

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 362)

1. Serious excess body mass contributes to heart disorders and circulatory problems such as high blood pressure. It places extra stress on bones and muscles and crowds the internal organs. Shortness of breath, tiredness, and emotional and social problems are also quite common.
2. Answers will vary considerably, but the answers can be used as the basis of some interesting discussion, leading to an understanding of differences between individuals, families, cultures, and socio-economic groups.
3. Milk group: 4 or more servings per day.
Meat group: at least 2 servings per day.
Fruits and vegetables group: at least 4 servings per day.
Bread and cereals group: 4 or more servings per day.
5. There should be a constant balancing of the food intake to match the energy demands of the body. Persons who work at physically demanding jobs require greater amounts of food than sedentary workers. Too much food (more than will be burned off by work and exercise) will make a person overweight.
6.
 - a) Increase the amount of exercise and activity to burn more kilojoules.
 - b) Substitute foods that are more nutritious but have less kilojoules (i.e., substitute fruit or carrot sticks for snacks of high-sugar "junk food").
 - c) Avoid excess carbohydrates and keep meals balanced. Simply cut back on the sizes of portions, refuse "second helpings", push away from the table rather than sit and nibble.
 - d) Other answers will be offered.

Text Activities

ACTIVITY 1: (TEXT, PAGE 363)

ACTIVITY OBJECTIVES

1. to increase the students' awareness of what they eat
2. to determine if students are eating balanced diets
3. to show students how they can adjust their diet to maintain weight control
4. to demonstrate that diet should be varied according to activity level

PREPARATION TIPS

This exercise takes time, but it is time well spent. Many students have reported that this was the most useful and practical exercise they ever did in school science. It is important that students understand the values and purpose of the activity. While some of the work must be done outside the laboratory, class time should be scheduled so that students can get help with tables and calculations and have the opportunity to ask questions about the foods they eat.

A word of warning: many student records will include amounts of alcohol that may surprise you. This appears in records of both males and females. The total number of kilojoules may exceed what is normally considered the average input value for food during an entire day. Accept these figures at face value; they are rarely exaggerated in the hope of shocking you. Avoid the temptation to make a moral judgment, but try to help them recognize that alcohol has no food value and only provides kilojoules (see Table 14.3, page 337 in the text). You may feel that some senior students have drinking habits that suggest potential alcoholism. Figures from addiction clinics in many centres will support your suspicions. This may be the appropriate time to teach a class on the effects of alcohol in the body from a biological viewpoint (see pages 312-313 of the text). If the reports warrant it, you may wish to invite a speaker from a local addiction clinic or a doctor to discuss the problem from a medical standpoint.

ACTIVITY 2: DO I HAVE TOO MUCH MASS OR TOO LITTLE? (TEXT, PAGE 369)

MATERIALS

scales, tape measure, height/mass tables

ACTIVITY OBJECTIVES

1. to show that height/mass tables provide only a rough guide because they represent an average mass against an average height
2. to show that height/mass tables do not take into account individual differences

ANSWERS TO QUESTIONS

1. Answers will vary.
2. There are limited advantages with this technique for the reasons given above.

3. Insurance companies are interested in the risk a person represents when the person insures his or her life. Persons who are greatly overweight are poor risks for insurance companies.

ACTIVITY 3: TO CALCULATE YOUR IDEAL MASS (TEXT, PAGE 371)

MATERIALS

skin calipers, scales

ACTIVITY OBJECTIVES

1. to use a method that is an individual assessment, not a comparison to an average figure
2. to show that this method uses a direct measurement of the fat present in the body
3. to show a method that can be repeated to show changes
4. to allow the student to assess the results

PREPARATION TIPS

Beware of having students work in pairs for this activity for a great variation in the technique of using the calipers will result. It is best to train one or two students to use the calipers in a specific area (i.e., hip and abdomen). These students can rapidly take the measurements of all the students. Errors such as taking the hip measurement at right angles to that shown in the diagram can produce significant differences.

The caliper technique does not work well with extremely thin persons. Results are often distorted in these cases. Remember that even the average student in North America is a few kilograms above the healthy ideal mass and we have come to accept this as normal.

If students find their results suggest that they are more overweight than they expected, do not hesitate to remind them that an individual's ideal mass is the mass that makes the individual look and feel good, and provides the individual with adequate reserves for the body's needs. They can make adjustments to put their results into perspective, but they should try to remain as objective as possible. Usually, about 75% of the class accepts the caliper results as quite realistic.

SPECIAL NOTE

THE TABLES AND TECHNIQUES USED HERE HAVE BEEN SIMPLIFIED FOR HIGH SCHOOL STUDENTS. THE ORIGINAL DATA WAS DERIVED FROM STUDIES DONE ON PERSONS 18-20 YEARS OF AGE. IT APPEARS THAT MOST OF THE CLASS-ROOM RESULTS SHOW AN IDEAL MASS THAT IS ABOUT 5 kg GREATER THAN IS REALISTIC.

Questions

The answers will vary with each individual.

Additional Activities

ACTIVITY 15.A: FRAME SIZE ESTIMATION - WRIST TECHNIQUE

A method devised in the early 1960's used the diameter of the wrist to measure frame size. An individual's mass could then be considered in relation to his or her own body structure, rather than in relation to some average frame size. The bones of the wrist are very close to the surface and a tape measure can be used easily to record wrist diameter. This technique assumes that if the bones of the wrist are large, then all the bones of the body will be large in proportion, an assumption known as Hippe's Rule of the Wrist.

If we accept this general idea, we can use the size of the wrist to make some reasonable estimates of the body frame size. That is, we can determine if the individual is large- or small-boned.

MATERIALS

tape measure

METHOD

Carefully measure the circumference of the wrist just above the bump of the end of the ulna bone. Use the table to determine your frame size.

- Select the line of the table corresponding to your height.
- Find the group of wrist measurements in which your wrist size fits. Look at the top of the column and find your frame size.

TABLE: FRAME SIZE ESTIMATION

CIRCUMFERENCE OF THE WRIST IN CENTIMETRES			
Height in cm	Small Boned	Medium Boned	Large Boned
Under 162.5	Less than 14 cm	14-14.5 cm	Over 14.5 cm
162.5	Less than 15.2 cm	15-16 cm	Over 16 cm
Over 162.5	Less than 16 cm	16-16.5 cm	Over 16.5 cm

You might like to see how close you come to these proportions based on the size of the bones of the wrist.

Chest measures $5\frac{1}{2}$ times the wrist.

Waist measures 4 times the wrist.

Hips measure 6 times the wrist.

Thigh measures $3\frac{1}{2}$ times the wrist.

Calf measures $2\frac{1}{2}$ times the wrist.

Ankle measures $1\frac{1}{2}$ times the wrist.

HANDOUT

ACTIVITY OBJECTIVES

1. to demonstrate that bone or frame size affects body mass

PREPARATION TIPS

This method is not recommended as an ideal way to establish body size, but it does seem to be surprisingly accurate with students of average proportions. The short chart that compares the size of the wrist with various parts of the body is of considerable interest to many young people.

Self-test: Select the best answer

1. How many servings from the milk group are recommended for teenagers?
 - a) 1
 - b) 2
 - c) 3
 - d) 4 or more
2. If Jack takes a summer job which involves heavy manual labour he should
 - a) eat more protein to build muscle tissue
 - b) increase the number and/or size of portions in each food group
 - c) eat more carbohydrates to give himself extra energy
 - d) drink more milk
3. What is the average intake of kilojoules each day for a female between the ages of 15 and 18?
 - a) 7000 kJ
 - b) 9000 kJ
 - c) 11 000 kJ
 - d) 13 000 kJ
4. Which of the following meals has the best balance of the four food groups?
 - a) milk, cereal, apple
 - b) bacon and egg, toast, fruit juice, milk
 - c) cereal with fruit and milk, coffee
 - d) tea, peanut butter and banana sandwich
5. Which of the following is not usually included in the meat group?
 - a) fish
 - b) eggs
 - c) nuts
 - d) macaroni
6. Which of the following is not a correct statement?
 - a) Fruits and vegetables provide a valuable source of vitamins and minerals.
 - b) The major value of proteins is to supply the body with energy.
 - c) The milk group supplies the body with a major portion of its calcium needs.
 - d) Cereals provide energy and proteins.
7. Which of the following is not a correct statement?
Excess body mass contributes to
 - a) heart and vascular disorders
 - b) reduced blood pressure
 - c) adverse effects upon the bones
 - d) shortness of breath and weariness
8. Which of the following is the best answer?
 - a) Improper diet can contribute to learning difficulties.
 - b) Food additives can cause or increase problems in hyperkinetic children.
 - c) Some foods produce allergic responses in some people.
 - d) Poor maternal diets, before and during pregnancy, can affect both the physical and mental health of the baby.
 - e) All of the above are correct.
9. Exercise is a valuable activity because
 - a) it helps a person to feel and look good
 - b) it improves and maintains respiratory performance
 - c) it improves the cardiovascular system
 - d) All of the above are correct.

continued . . .

10. Height and mass tables
- a) are based upon the average height and mass of a large number of individuals
 - b) are used by insurance companies to determine risk factors when people apply for life insurance
 - c) make no allowance for differences in frame size
 - d) All of the above are correct.

ANSWERS TO SELF-TEST

- | | | | |
|----|----|-----|----|
| 1. | d) | 6. | b) |
| 2. | b) | 7. | b) |
| 3. | b) | 8. | e) |
| 4. | b) | 9. | d) |
| 5. | d) | 10. | d) |

Additional Resource Material

TABLE: FOOD AND EXERCISE ENERGY EQUIVALENTS

				Time in min to burn off kJ			
FOOD	MASS (g)	kJ	Cal.	WALK	BICYCLE	SWIM	JOG
Coke (227 mL)	240	483	115	20	16	12	11
White bread (1 slice)	23	252	60	12	9	7	6
Mars Bar	40	890	212	40	32	25	21
Peanut brittle	25	462	110	21	16	13	11
Popcorn (buttered) 250 mL	18	344	82	16	12	10	8
Choc. chip cookie (1)	11	210	50	10	8	6	5
Oreo creme cookie (1)	12	168	40	8	6	5	4
Ice cream sandwich	75	873	208	40	32	25	21
Ice cream cone	72	672	160	31	24	19	16
Banana split	300	2494	594	114	89	71	59
Doughnut (Jelly)	65	949	226	44	34	27	23
Apple	150	365	87	17	13	10	9
Banana	150	533	127	24	19	15	13
Cheeseburger	180	1940	462	89	69	55	46
French fries (20)	100	1150	274	53	41	33	27

This is a reproduction of Table 15.2, page 359 of the text, with the Calorie units added.

TABLE: SOME POPULAR FAST TAKE-OUT FOODS

	kJ	Cal.
Hamburger (bun included)	1050	250
Hamburger, double	1365	325
Whopper	2646	630
Cheeseburger	1280	305
Cheeseburger deluxe	2520	600
Big Mac	2340	557
French Fries	966	230
Onion Rings	1260	300
Fried Chicken 2-piece dinner	2457	595
Fried Chicken 3-piece dinner	4135	980
Chili Dog	1386	330
2 Fish, Cole Slaw, Chips	3108	740
Chopped Steak, 112 g	1373	327
Chopped Steak, 224 g	2742	653
Baked Potato	1016	231
Salad Dressing	630	150
Pizza (average) $\frac{1}{2}$ of 25 cm	1953	465
Pizza (average) $\frac{1}{2}$ of 35 cm	3780	900
Pizza (average) $\frac{1}{2}$ of 45 cm	5040	1200
Egg McMuffin	1310	312
Hot Cakes, Butter	1142	272
Milk Shake	1428	345
Dairy Queen Small Cone	462	110
Dairy Queen Medium Cone	966	230
Dairy Queen Large Cone	1428	340
Dipped Small Cone	676	160
Dipped Medium Cone	1302	310
Dipped Large Cone	1890	450
Dairy Queen Sundae (S)	788	190
Dairy Queen Sundae (M)	1260	300
Dairy Queen Sundae (L)	1806	430
Hot Fudge Sundae	2436	580
Banana Split	2436	580

This is a reproduction of Table 15.4, pages 364-65 of the text, with the **Calorie units** added. (Extracted and Adapted from several sources including the *Fast Food Calorie Counter* by H. Jordan, L. Levitz, and G. Kimbrell.)

TABLE: ACTIVITY AND ENERGY FACTORS

ACTIVITY	ENERGY FACTORS			
	kJ/h	Cal/h	kJ/min	Cal/min
Sleeping	4.1	60	0.07	1.0
Sitting	5.2	74	0.09	1.2
Writing & Studying	6.0	81	0.10	1.4
Standing relaxed	6.3	86	0.11	1.4
Singing, Sewing,				
Dressing, Washing	7.1	102	0.13	1.5
Dishwashing	8.1	115	0.14	1.9
Playing cards, Typing	9.0	128	0.15	2.1
Dusting & Sweeping	10.5	150	0.18	2.5
Washing the car,				
Cooking,				
Piano-playing	11.2	160	0.19	2.6
Walking (3.2 km/h)	11.6	165	0.19	2.7
Bowling	13.6	195	0.23	3.2
Canoeing (1.5 km/h)	14.2	202	0.24	3.4
Sailing	15.8	225	0.26	3.7
Bicycling (3.0 km/h)				
Walking (4.8 km/h)	16.2	231	0.27	3.8
Table tennis	18.0	257	0.30	4.3
Laundry, by hand	18.6	265	0.31	4.4
Walking (6.4 km/h)	20.6	294	0.34	4.9
Volleyball, Roller skating,				
Badminton	21.5	307	0.36	5.1
Dancing, slow	22.6	322	0.38	5.4
Bicycling (15.3 km/h)	25.8	368	0.43	6.1
Hiking (or hunting),				
Dancing, fast, Shovelling	27.0	385	0.45	6.4
Water-Skiing,				
Tennis, Downhill skiing	36.2	516	0.60	8.6
Climbing stairs,				
Running (8.8 km/h),				
Swimming (breast stroke				
36.6 m/min)	37.5	536	0.62	8.9
Bicycling (20.9 km/h)	40.5	578	0.67	9.6
Rowing, Cross-country				
skiing	42.0	599	0.70	10.0
Ice skating (vigorous)	48.8	696	0.81	11.6
Swimming (Crawl,	49.1	701	0.81	11.6
45.7 m/min)				
Handball	49.5	705	0.82	11.8
Running (12.9 km/h)	62.0	885	1.03	14.7
Cross-country skiing				
(competitive)	73.6	1051	1.26	17.5

This is a reproduction of Table 15.5, pages 366-67 of the text, with the Calorie units added. (Adapted from *Lazy Man's Guide to Fitness* by K. D. Rose and J. D. Martin.)

TABLE: RECOMMENDED DAILY NUTRIENT INTAKE

AGE (YEARS)		13-15		16-18		19-35	
SEX		Male	Female	Male	Female	Male	Female
Water-Soluble Vitamins	Mass (kg)	51	49	64	54	70	56
	Height (cm)	162	159	172	161	176	161
	Energy (kJ)	11 700	8 200	13 400	8 800	12 600	8 800
	Energy (Cal.)	2 800	2 200	3 200	2 100	3 000	2 100
	Protein (g)	52	43	54	43	56	41
	Thiamin (mg)	1.4	1.1	1.6	1.1	1.5	1.1
	Niacin (NE)	19	15	21	14	20	14
	Riboflavin (mg)	1.7	1.4	2.0	1.3	1.8	1.3
	Vitamin B ₆ (mg)	2.0	1.5	2.0	1.5	2.0	1.5
	Folate (µg)	200	200	200	200	200	200
Fat-Soluble Vitamins	Vitamin B ₁₂ (µg)	3.0	3.0	3.0	3.0	3.0	3.0
	Vitamin C (mg)	30	30	30	30	30	30
	Vitamin A (RE)	1 000	800	1 000	800	1 000	800
	Vitamin D (µg)	2.5	2.5	2.5	2.5	2.5	2.5
	Vitamin E (mg)	9	7	10	6	9	6
Minerals	Calcium (mg)	1 200	800	1 000	700	800	700
	Phosphorus (mg)	1 200	800	1 000	700	800	700
	Magnesium (mg)	250	250	300	250	300	250
	Iodine (µg)	140	110	160	110	150	110
	Iron (mg)	13	14	14	14	10	14
	Zinc (mg)	10	10	12	11	10	9

This is a reproduction of Table 15.6, page 368 of the text, with the Calorie units added. (Courtesy Health and Welfare Canada)

TABLE: EASY EATING WITH CANADA'S FOOD GUIDE

	What to eat for WEIGHT CONTROL	What to eat for CONVENIENCE
MILK and MILK PRODUCTS Children (up to 11 years) -2-3 servings Adolescents-3-4 servings Pregnant and nursing women-3-4 servings Adults-2 servings	Low calorie milk choices such as: 2 per cent or skim milk; plain yogurt; buttermilk; uncreamed cottage cheese; skim milk cheese	All milk products are convenient: fluid milk; ice cream; yogurt; milk- based soup; cheese
MEAT and ALTERNATIVES 2 servings Examples include: poultry, fish, liver, meat, peanut butter, dried peas, beans or lentils, nuts, cheese, eggs	Choose small (80 g) servings of boiled, broiled, or roasted lean meats. Trim off visible fat. Pass up the gravy! Eggs, fish, poultry	Peanut butter; hamburgers; hot dogs; sliced luncheon meats; baked beans with pork; cheese; eggs
BREAD and CEREALS 3-5 servings of whole- grain or enriched products. Examples include: bread, cereals, rice, macaroni, spaghetti	Remember to include these foods; they contribute important nutrients: plain rolls and biscuits; unsweetened cereals; bread (use less butter, jam, etc.)	Bread; ready-to-eat cereals; muffin and tea biscuit mixes; ready- made or bake-and-serve rolls
FRUITS and VEGETABLES 4-5 servings Include at least 2 vegetables. Choose a variety of both vege- tables and fruits, cooked, raw, or their juices. Include yellow or green or green leafy vegetables	Choose these foods in their lowest energy form: e.g., apple instead of apple pie, unsweetened juices; baked, steamed, boiled, or raw vegetables; vegetables served without butter, sauces, and gravy; green salads	Choices requiring little or no preparation time: juices; fresh fruit, canned or frozen fruit and vegetables; dried fruit, e.g., raisins, tossed green salads, raw vegetables

How to CUT COSTS	Nutritious SNACKING	Selections for EATING OUT
Milk products are high in nutrients - a good buy; skim milk powder; canned milk; block cheese; cottage cheese	Milk; milkshakes; ice cream; cheese; eggnogs	Milk; milkshakes; yogurt; custard or milk puddings; cheese; milk soups; ice cream
Consider cost per serving not cost per kilogram, when buying meat. Watch for weekly specials. Use less meat and more meat substitutes such as macaroni and cheese; peanut butter and bread, baked beans, eggs	Snacks for hearty appetites: cold meat slices; cheese; hard-cooked eggs; nuts; hot dogs; peanut butter and bread	Pizza; lasagna; hot dogs; hamburgers; fried chicken; fishburgers; omelettes; other meat; fish; poultry; cheese; egg dishes
Use breads and cereals to stretch protein foods in casseroles and meat loaves. Long-cooking cereals; day-old bread for toast; puddings	Muffins; biscuits; ready-to-eat cereals; bread; toast; crackers	Pancakes; crepes; bran muffins; pasta dishes - spaghetti, lasagna; bread; rice pudding
Nutrients are about the same in fresh, frozen, or canned fruits and vegetables, so buy the least expensive. Fresh produce in season. Usually store brands are less expensive. Use leftovers in soups or stews	Juices, fresh fruit, combinations such as: fruit and cottage cheese; fruit and cheese kebobs; raw vegetables nibblers, e.g., carrot sticks, green peppers, tomatoes with yogurt as dip	Vegetable soups and juices; side salads; tossed salad; coleslaw; vegetables with the entree; fruit cup and fruit salad plates

(Adapted from *Canada's Food Guide*, Health and Welfare Canada, 1982)

TABLE: WARM-UP EXERCISES AND WORKOUT

A) WARM UP EXERCISES

EXERCISE	WHAT TO DO	COMMENTS
Arm circles	Arm circling, keep the circles as large as possible.	10 forward and 10 backward.
Side bends with a towel	Stretch a towel over your head, slowly stretch from side to side, bending from the hips. Hold the position, stretch briefly and then straighten up. Relax.	5 bends to each side. Keep the towel handy; it can be used for many isometric exercises.
Toe touches	Stand with your legs well apart. Bend down and touch the floor with your hands. Slowly walk the hands back below the hips. Hold. Now walk the hands back again. Stretch up and relax. Use a towel stretched over your head; bend down slowly keeping the towel tight. Touch the towel to ankles or toes, stretch up with the towel above your head. Arms down and relax.	Repeat the exercise 10 times. Remember in all these exercises to start with a small number of exercises and gradually increase the number. Keep a balance by exercising each part of your body.
Ham string and calf stretch	Sit on the floor with one knee bent and out to the side. The other leg should be straight in front of you. Reach forward and grasp the ankle of your outstretched leg. Lower your head towards your knee. Hold for 5-10 s. The foot of your straight leg should remain flexed.	Repeat 3 or 4 times with each leg.
Jog on the spot or skipping	Running on the spot, bouncing on alternate feet, skipping, or shadow-boxing.	Vary your time but don't try for long periods or tire yourself. Loosen up the muscles after the stretching.

continued . . .

B) THE WORKOUT Rest for 10-30 s after each activity.

Chair dips	Place two strong kitchen chairs back to back with enough room for your body between them. Rest your toes on the floor and place your straightened arms down and grasp the backs of the chairs. Push up. Now keeping your toes together, raise your legs, hold, then lower.	Hold the position for several seconds, and relax for about 10 s. Repeat about 8 times; do more as you feel capable. Try also to increase the holding time as you progress. Warning: Make sure that the chairs are strong and properly placed.
Sit ups	Start as described in the TV exercises. As you build up the muscles, increase the difficulty. Place your hands behind your head, curl upward until your elbows touch your knees. Slowly lower yourself back to the floor.	Keep the exercise going for about 30 s at the start; increase this as you feel capable. Remember: don't force your body to do anything that is painful.
Jumping	Stand relaxed, knees flexed, and go half way down, straighten and jump up. Work rhythmically. Use a small, strong box or bench and jump up onto the bench from an astride position. Another alternative is astride jumping with arm raising.	Start with about 15 s and increase as you wish.
Side hip and leg raising	Lie on your side, one hand on the floor supporting the upper body. Lift the hips, keeping the body straight from toe to head. Raise the upper leg, hold, lower, and relax. Repeat on the other side.	30 s. 15 s on each side.
Aerobic activity	Select an exercise that will force you to breathe deeply and increase the heart rate. Some suggestions. Skipping, this is excellent if you have headroom indoors. Indoor bicycle, run around the block, vigorous dancing. Swimming or cross-country skiing, if you can fit them into your weekly routine.	8 min or more.
Relaxation	Put on some quiet music, sit or lie down, and close your eyes. Breathe deeply, but regularly. Try to consciously let each part of your body relax. Let your mind also relax, allow the music to flow over you without concentrating on the sounds.	3-4 min minimum.

(Adapted from a program by Government of Canada. Fitness and Amateur Sport.)

NOTE: Exercises should be carried out with smooth movements. Do not force your body into any movements that are painful.

Selected Readings

1. Anderson, James and Martin Cohen, *The West Point Fitness and Diet Book* (Rawson Assoc. Publ., 1977).
2. Atkins, Robert and Shirley Linde, *Dr. Atkins Sugar Energy Diet* (New York: Crown Publishers, 1977).
3. Davis, Adelle, *Let's Have Healthy Children* (Scarborough, Ont.: New American Library of Canada Ltd., 1972).
4. Morehouse, Laurence *et al*, *Total Fitness* (New York: Simon and Schuster, 1975).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "For Tomorrow We Shall Diet." 24 min col., Churchill Films
2. "Eat, Drink and Be Wary." 16 min col., Churchill Films

FILMSTRIPS

See Chapter 15.

1. "Diet and Health." Visual Education Centre, Canada Ltd.

Unit VIII

How the Body Removes Wastes from the Blood

Chapter 16

The Excretory System

Chapter Focus

The human body is extraordinarily efficient. Very little waste is produced in spite of the enormous number of complex processes which are constantly active within the body. However, the wastes that do accumulate must be excreted quickly because they rapidly build up to toxic proportions that are extremely hazardous. Students should recognize that wastes are excreted as gasses through the lungs, as dissolved substances in urine, and as solids through the alimentary canal. These last substances have never really entered the body systems and are not end products of body functions but, rather, substances in food that the body cannot digest or use.

The body's ability to recycle materials (parts of red blood cells, bile, etc.) is an important concept. The body also has the ability to reclaim materials that pass through the kidneys (such as water and glucose).

The activity of nephrons is difficult for general level students to comprehend. It is probably sufficient that they recognize that the function of nephrons is to remove wastes, while retaining useful substances for the body. The useful substances are reabsorbed, and the waste products are concentrated in the urine for elimination.

Objectives

After studying this chapter, the student should be able to

- state the general functions of the excretory system
- explain why the skin and lungs are classed as excretory organs
- describe the size, location, and general structure of the urinary bladder, kidneys, ureters, and urethra
- describe in detail the structure of the kidney and the nephron
- explain the process of filtration and reabsorption that takes place in the nephron
- describe the action of the antidiuretic hormone
- describe what causes the various substances to cross the membranes of the nephron and capillaries
- list the substances that are present in normal urine

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
Excretion Through the Lungs		*
Excretion Through the Skin and Anus		*
The Organs of the Excretory System	*	
The Kidneys	*	
The Structure of the Kidneys	*	
The Nephron	*	
The Formation of the Filtrate	*	
The Tubules	*	
Reabsorption in the Tubules	*	
The Collection of Urine		*
The Antidiuretic Hormone (ADH)		*
The Composition of Urine		*
The Ureters	*	
The Urinary Bladder	*	
The Urethra	*	

Teaching Suggestions

Before beginning this section, the teacher should decide how much content should be taught and how detailed it should be. A very conservative assessment of the ability of the class should be made. It is better to cover the general principles of the excretory system and avoid the detailed processes in order to allow time to deal with topics that are more valuable for life skills, than to spend time covering material that is poorly understood and quickly forgotten.

The functioning of the kidney nephrons is difficult for general level students to understand. Some teachers may wish to work from Figure 16.5, page 384, in the text. Detailed discussion of sodium pumps and active transport is probably beyond what is necessary for students to know at this level.

Students often forget how small the nephron is and that there is an incredibly large number of these structures packed into each kidney. An idea to emphasize is that each nephron produces only the most minute amount of urine, but that the total amount of urine produced by all the nephrons during 24 h is appreciable.

A general idea of what urine contains, and how this can be analysed and used as a diagnostic measure by the doctor, should be one of the general objectives in studying this topic. So many people submit to a battery of tests conducted by their doctor without understanding what is being done, or why. Many of them would ask more questions of the mechanic who fixes their cars, than they do about their own bodies. A basic knowledge about the body, in health and in sickness, is fundamental in a course in Human Biology. With this knowledge, each student can appreciate the stresses that are placed upon the body.

The section in the Collegiate Minicourse programme of B.S.C.S. "Animal Structure and Function" has some useful exercises for student activities. You should check with your own Provincial Kidney Foundation for free literature;

they are extremely helpful and can supply some excellent resource material. Also, the film, "The Work of the Kidneys", is excellent for this topic (see "Visual Aids").

Interest Box. The Artificial Kidney. (text, page 386-87)

This box may help answer some of the questions that arise about the artificial kidney and lead to some interesting discussion about the organ donor system used in Canada. Most students will have a driver's licence and be aware of the space that can be used to legally donate organs for medical use. It is also worth discussing where and how doctors get the experience and practice to achieve surgical skills. (Would the student like to be the first patient on whom a young doctor ever operates, or even the first customer of a novice hairdresser?) The need for cadavers for the development of experimental techniques, such as heart transplants, is worth discussing. The development of new medical drugs, the use of animals and volunteers, and how information is fed back to researchers, are all valid topics to study (although they need not be considered part of the structured, tested requirements of the course).

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 391)

- | | |
|-------------------------|--------------------|
| 1. ureter | 6. proximal tubule |
| 2. nephron | 7. urethra |
| 3. aorta (renal artery) | 8. filtrate |
| 4. glomerulus | 9. sphincter |
| 5. kidney | 10. urea |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 391)

1. See Figure 16.1a, page 379, in the text.
2. A molecule of water passes out of the glomerulus and into the Bowman's capsule. Then, as part of the filtrate, it passes through the proximal tubule, loop of Henle, distal tubule, collecting tubule, renal pelvis, ureter, urinary bladder, and, finally, the urethra.
3. Large numbers of nephrons are required, as each nephron filters only a very small amount of the blood plasma. The substances filtered and reabsorbed are dissolved in the plasma and, therefore, they require very specific and accurate reabsorption in order to separate the different molecules.
4. The filtrate crosses the membranes between the glomerulus and the Bowman's capsule, due to the high arterial pressure produced in the renal arteries and the vessels that feed the glomerulus and the relatively low pressure on the inside of the Bowman's capsule. Diffusion gradients also aid the passage of materials.

5. The membranes of the glomerulus and Bowman's capsule are selectively permeable. Only small molecules can pass. Cells and large molecules such as proteins are too large to cross.
6. The antidiuretic hormone affects the permeability of the distal and collecting tubules and thus determines how much water will be reabsorbed and how much will be allowed into the ureters to dilute the urine. As a result, it also determines the amount of water present in the blood plasma.
7. Diffusion refers to the movement of molecules from a high concentration to a low concentration by random molecular movement. Active transport involves the passage of molecules against the concentration gradient, from a low to a high concentration. This process requires the input of energy and the help of carrier molecules or some other "pump" action. Osmosis involves the movement of water molecules only.
8. See Table 16.4, page 389, in the text.
9. The composition of the filtrate contains a dilute solution of both wanted substances, which are later reabsorbed, and wastes. Urine contains a concentrated solution of wastes.

ACTIVITY 1: ANALYSIS OF URINE (TEXT, PAGE 392)

PREPARATION TIPS

Students require some preparation for this activity as some will find the subject embarrassing. First, explain why urinalysis tests are made (see below). Then, explain that the test is made at home and all that is necessary is the moistening of the strip according to the manufacturer's directions. (Avoid over-moistening as some of the chemicals can be washed off the strip.)

Urine tests are best taken in the morning. They should not be taken after heavy exercise, because this may indicate misleading protein and sugar levels. Menstruation can also produce modified results.

VALUES OF URINALYSIS

Some of the substances found in the urine are normal and their quantities can be checked. Others may be abnormal and this helps the doctor diagnose a particular disorder. The doctor may then order more specific tests. Urine samples may show the following:

1. Glucose: usually only present in very small amounts if at all.
2. Protein: also not normally found in any quantity.
3. Ketones: normally not present in any quantity.
4. pH: urine is normally slightly acid, but may vary from pH 5 (acid) to pH 8 (alkaline).
5. Bilirubin (a bile pigment released by the liver when wornout blood cells are broken down): usually not present.
6. Urobilinogen (a type of bilirubin from the intestine): normally not present except in very small amounts.
7. Blood: normally not found in the urine.

MATERIALS

urinalysis combistick, comparison colour charts, watch, pencil and paper for recording
(Time the strip according to the directions displayed by the manufacturer.)

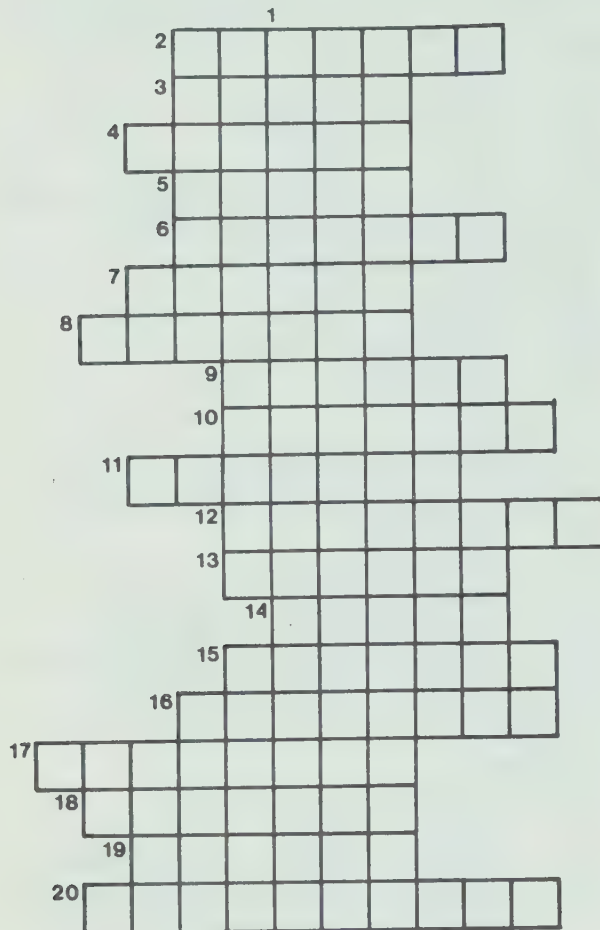
ANSWERS TO QUESTIONS

1. Abnormal amounts of sugar might be present after any very high sugar intake from candy, sugar-rich drinks, etc.
2. Ketones are formed by the body when fats, rather than carbohydrates, are providing energy. Special low carbohydrate diets or long periods without food may cause ketones to appear. A normal ketone level would be zero.
3. pH is a measure of the acidity or alkalinity of a substance. Generally accepted levels range between a pH of 5 and 8.
4. Bilirubin is produced by the liver when red blood cells are destroyed.
5. If proteins are found in the urine, it is possible that the membrane of the Bowman's capsule and the capillaries of the glomerulus are not functioning properly since proteins and blood cells are not normally able to pass through these membranes. Blood in the urine might also indicate some internal bleeding at some junction along the urine pathway.

Self-test: Select the best answer

1. Which of the following is not an organ of excretion?
 - a) skin
 - b) stomach
 - c) rectum
 - d) lung
 - e) kidney
2. The major function of the kidneys is the elimination of
 - a) salts
 - b) water
 - c) nitrogenous wastes
 - d) carbon dioxide
 - e) undigested food
3. Which of the following is not found in the filtrate?
 - a) glucose
 - b) proteins
 - c) water
 - d) salts
 - e) nitrogenous wastes
4. The part of the kidney which is composed of a ball of capillaries is the
 - a) Bowman's capsule
 - b) loop of Henle
 - c) glomerulus
 - d) proximal tubule
 - e) distal tubule
5. The tube leading from the kidney to the bladder is the
 - a) ureter
 - b) urethra
 - c) renal artery
 - d) renal vein
 - e) collecting tubule
6. The part of the nephron in which most of the sodium is reabsorbed is
 - a) the proximal tubule
 - b) loop of Henle
 - c) distal tubule
 - d) Bowman's capsule
7. Which of the following substances is not reabsorbed as the filtrate passes through the nephron?
 - a) water
 - b) glucose
 - c) nitrogenous products
 - d) salts
8. Substances are reabsorbed into the capillaries from the tubules by
 - a) diffusion
 - b) active transport
 - c) osmosis
 - d) All of these are correct.
 - e) None of these answers is correct.
9. The blood that passes out of the kidney
 - a) has been cleaned of all waste products
 - b) contains some waste products
 - c) has had about one-fifth of the plasma it contained filtered and cleaned
 - d) Both b) and c) are correct.
10. The bladder is emptied by
 - a) reflex action
 - b) voluntary control
 - c) The bladder is under reflex control and the external sphincters are under voluntary control.
 - d) Both the bladder and external sphincter are under voluntary control.

Crossword



DOWN

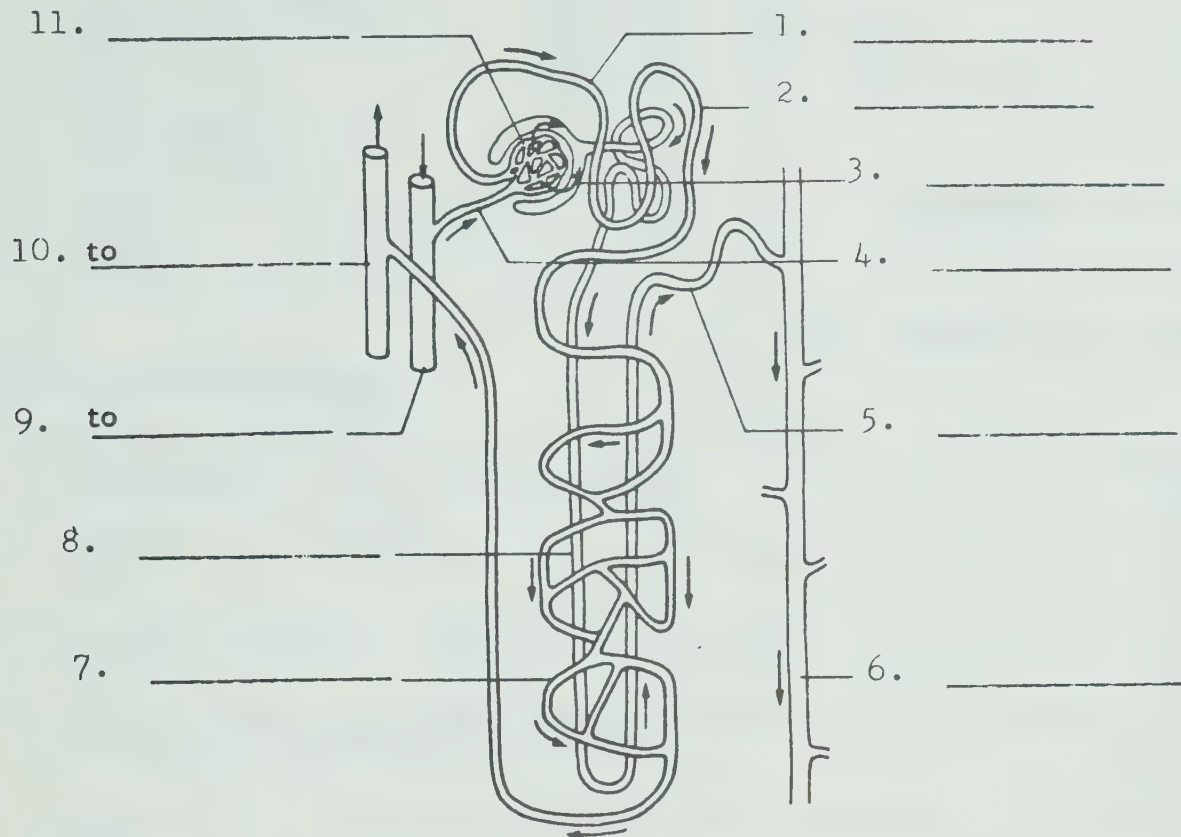
1. pituitary secretion that controls water balance in the kidneys (two words)

ACROSS

2. sac where urine is stored
3. name of artery entering the kidney
4. convoluting tubule after the loop of Henle
5. excretory product of the kidneys
6. central part of kidney containing capillaries and many tubules
7. important salt moved out of the loop of Henle by active transport
8. Bowman's sheath
9. tube from kidney to bladder
10. microscopic filtering units in the kidney
11. tube leading out of the bladder
12. substance that crosses from the glomerulus to the Bowman's capsule
13. type of transport that requires energy to help molecules cross a membrane against the concentration gradient
14. name of the tiny loop within the nephron
15. name of the capsule that surrounds the glomerulus
16. triangular structures within the kidney
17. the first convoluting tubule
18. sugar sometimes present in the urine
19. bean-shaped organ in the abdomen that helps clean out wastes from the blood
20. the final tubule of the nephron (Many nephrons empty into this tubule.)

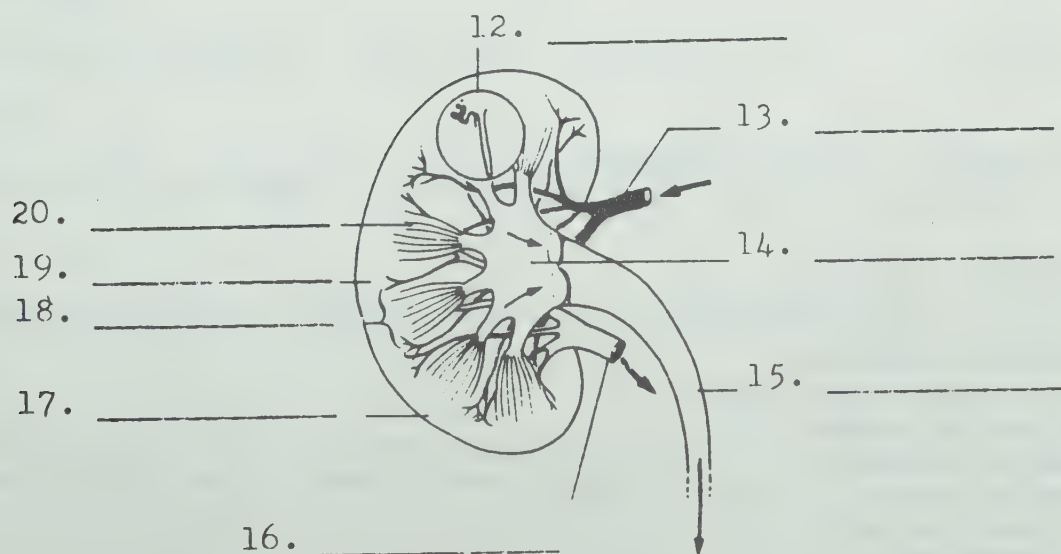
The Nephron

Fill in the blanks with the correct labels.



The Kidney

Fill in the blanks with the correct labels.



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. b) | 6. b) |
| 2. c) | 7. c) |
| 3. b) | 8. d) |
| 4. c) | 9. d) |
| 5. a) | 10. c) |

ANSWERS TO CROSSWORD

DOWN

1. antidiuretic hormone

ACROSS

- 2. bladder
- 3. renal
- 4. distal
- 5. urine
- 6. medulla
- 7. sodium
- 8. capsule
- 9. ureter
- 10. nephron
- 11. urethra
- 12. filtrate
- 13. active
- 14. Henle
- 15. Bowman's
- 16. pyramids
- 17. proximal
- 18. glucose
- 19. kidney
- 20. collecting

LABEL ANSWERS TO "THE NEPHRON"
(Taken from Figure 16.3, text page 381)

- 1. efferent arteriole
- 2. proximal convoluted tubule
- 3. Bowman's capsule
- 4. afferent arteriole
- 5. distal convoluted tubule
- 6. collecting tubule
- 7. capillary network
- 8. loop of Henle
- 9. to renal artery
- 10. to renal vein
- 11. glomerulus

LABEL ANSWERS TO "THE KIDNEY"

(Taken from Figure 16.2, text page 380)

12. location of nephrons
13. renal artery
14. renal pelvis
15. ureter
16. renal vein
17. fibrous capsule
18. pyramids
19. cortex
20. medulla

Selected Readings

1. Collegiate Minicourse Program. B.S.C.S. "Animal Structure and Function" (Philadelphia: W. B. Saunders, 1976).
2. Guyton, A. C., *Physiology of the Human Body* (Philadelphia: W. B. Saunders, 1977).
3. "Kidney Foundation." Pamphlets available from Provincial Units.
4. McClintic, Robert J., *Basic Anatomy and Physiology of the Human Body* (New York: John Wiley & Sons, 1980).
5. Sullivan, L. P., *Physiology of the Kidney* (Philadelphia: Lea and Febiger, 1974).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "The Work of the Kidneys." 20 min col., EBE

FILMSTRIPS

1. "The Urinary System." Visual Education Centre, Canada Ltd.

FILMLOOPS

1. "Reabsorption." Wards. Arbor Scientific, Ont.
2. "Formation of Urine." Wards. Arbor Scientific, Ont.

Unit IX

Chemical Control of the Body

Chapter 17

The Endocrine System

Chapter Focus

The human body is composed of trillions of cells, each with its own special function. These separate cells, which form the tissues and organs of the body, must be co-ordinated to perform as a single organism. Normally, a homeostatic situation must be established, but the body must be able to adjust for occasional imbalances, emergencies, or pregnancy. Chemical co-ordination is provided by the endocrine system and it accomplishes this in partnership with the autonomic nervous system.

This chapter covers the nature of hormones and the endocrine glands. It also includes endocrine malfunctions because the action of the endocrine glands becomes apparent by examining the malfunctions of the endocrine organs. Most endocrine malfunctions are relatively uncommon, and many students will never have seen a goitre or a pituitary giant, yet these disorders make homeostatic processes easier to understand and so should be included.

Objectives

After studying this chapter, the student should be able to

- differentiate between endocrine and exocrine secretions
- list the organs of the endocrine system
- label a diagram of the endocrine system or identify the location of the endocrine glands
- define a hormone
- define the general functions of each of the endocrine organs and give examples of disorders that result from oversecretion or undersecretion of these glands
- explain why the pituitary gland is described as a master gland
- list the major secretions of the pituitary gland and the target organs affected by each secretion
- define the term "homeostasis"
- explain the partnership between the endocrine and autonomic nervous system

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
What are the Endocrine Glands?	*	
The Role of Endocrine Glands	*	
Hormones	*	
The Organs of the Endocrine System	*	
The Thyroid Gland	*	
Thyroid Disorders		*
Parathyroid Glands		*
The Pancreas	*	
Insulin and the Control of Sugar	*	
Adrenal Glands	*	
Thymus Glands		*
The Gonads: The Ovaries and Testes	*	
The Pituitary Gland	*	
Hormones of the Anterior Pituitary Gland	*	
Hormones of the Posterior Pituitary Gland	*	
Pituitary Disorders		*
Homeostasis	*	
The Partnership Between the Endocrines and the Autonomic Nervous System		*

Teaching Suggestions

This is a difficult topic for the general level student to understand or remember. The terminology is quite difficult for these students. However, they are often fascinated by the disorders that malfunctions of these organs produce. For the slower classes, I often reduce the topic to a few general principles about hormones and deal fairly specifically with the adrenal glands. The remainder I may cover as an interest "lecture" showing slides of disorders (pituitary dwarfs, pituitary giants, goitre, etc.) with a simple description of the problem and how oversecretion or undersecretion of a hormone may affect the individual.

Insulin and the endocrine function of the pancreas is important and should be covered, particularly in terms of the student's own sugar intake and tolerance.

Photographs of endocrine disorders are a must for this topic. If you live in a large city, you may be able to get copies of professional photographs from a major hospital, but it is usually difficult to obtain permission from both doctor and patient for their release. The easiest way is to photograph, either with colour slides or positive black and white film, directly from a textbook. Most hospitals have a small professional library and are quite willing to have teachers use this facility. This can prove to be an excellent source of first-class material. I have sought permission to photograph pages of textbooks in some instances and have never been refused, but teachers must use their own discretion in this practice.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 412)

- | | |
|-------------------------|-------------------------|
| 1. goitre | 6. ovaries |
| 2. parathyroids | 7. antidiuretic hormone |
| 3. islets of Langerhans | 8. endocrine |
| 4. adrenalin | 9. hypothalamus |
| 5. adrenal | 10. hormones |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 413)

1. Homeostasis is the ability of the body to maintain a constant balanced state or condition. It applies, for example, to the maintenance of a steady temperature, a relatively constant number of red blood cells, and a relatively constant sugar level in the blood stream. The teacher may ask the students for other examples in the systems already studied.
2. The release of adrenalin into the blood stream causes an increased blood supply to skeletal muscles and the heart, an increased blood pressure, and dilation of the pupil of the eye. It relaxes the smooth muscles of the bronchiole walls and stimulates respiration. It increases the rate at which the heart pumps blood and contracts muscles in the skin producing "goose flesh". The blood supply to the skin is reduced. Blood coagulation is improved, glycogen is released by the liver to make energy available to the muscles. The bladder and ureters contract.
3. The pituitary gland is often referred to as the master gland because it releases many hormones that act upon, or control, the secretions of other endocrine glands in the body. See Figure 17.6, page 409, in the text.
4. Anterior pituitary gland: growth hormone, thyroid stimulating hormone, adrenocorticotrophic hormone, melanocyte stimulating hormone, follicle stimulating hormone, lutenizing hormone, interstitial cell stimulating hormone.
Posterior pituitary: antidiuretic hormone, oxytocin.
5. Parathyroid glands control the amounts of calcium and phosphorus in the blood. There are two pairs of glands located in the tissues of the thyroid gland below the Adam's apple in the neck. Removal of the parathyroid glands results in death.
6. The adrenal medulla produces adrenalin and noradrenalin. The cortex of the adrenal glands produces corticoids. These include aldosterone and cortisone.
7. The endocrine system works in partnership with the autonomic nervous system. Both these systems have a role to play in emergencies and in the return of the body to normal conditions after the emergency is over. The autonomic nervous system responds instantly and helps to trigger the adrenal hormones. However, the adrenal cortex hormones are effective

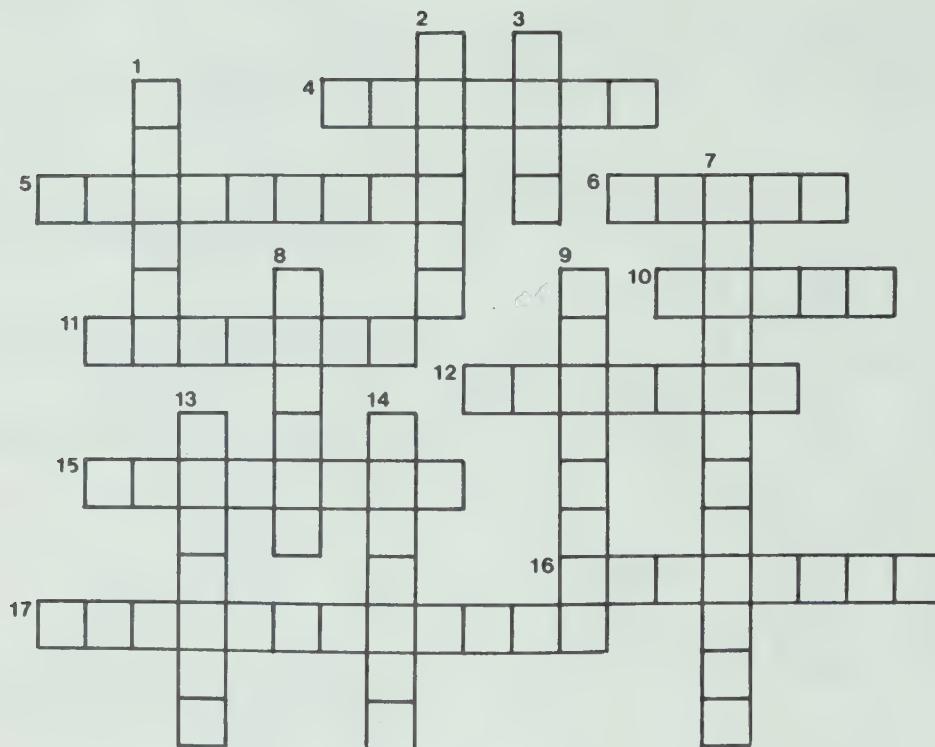
in preparing the body for long-term stress, rather than producing instant responses.

8. Hormone: a chemical messenger, produced in a gland and sent via the blood stream to a target organ where it produces a response.
Target organ: the organ that recognizes the hormone and reacts to its stimulus.
Metabolism: the chemical changes and processes that take place in living cells; all the activities of the cell (respiration, the building up and breaking down of molecules, etc.).
10. Diabetics may use up their stores of sugar more rapidly than they expect. As the stores become depleted, muscles cease to work effectively and become weak. Without a new supply of sugar that can be absorbed quickly, the individual may sweat or become drowsy and stagger. If treatment is not given, a coma and even death can result.

Self-test: Select the best answer

1. Which of the following hormones require iodine in the diet?
 - a) oxytocin
 - b) growth hormone
 - c) thyroxin
 - d) adrenalin
2. Glands that pour their secretions into the blood stream are called
 - a) endocrine glands
 - b) exocrine glands
 - c) parotid glands
 - d) lymph nodes
3. The pituitary gland is found
 - a) below the brain
 - b) below the sternum
 - c) over the larynx
 - d) on the top of the kidneys
4. Which of the following hormones affects the adrenal glands?
 - a) LH
 - b) FSH
 - c) TSH
 - d) ACTH
5. Which of the following hormones is not involved with the female menstrual cycle?
 - a) FSH
 - b) lutenizing hormone
 - c) progesterone
 - d) estrogen
 - e) prolactin
6. The hormone that regulates the levels of glucose in the blood is
 - a) thyroxin
 - b) insulin
 - c) melanin
 - d) adrenalin
7. The gland that gradually becomes less active after puberty is the
 - a) thyroid
 - b) parathyroid
 - c) thymus
 - d) pituitary
8. The glands found on top of the kidneys are
 - a) parathyroids
 - b) ovaries
 - c) adrenal glands
 - d) thyroid glands
9. A gland that has both endocrine and exocrine functions is
 - a) pancreas
 - b) pituitary
 - c) thyroid
 - d) thymus

Crossword



ACROSS

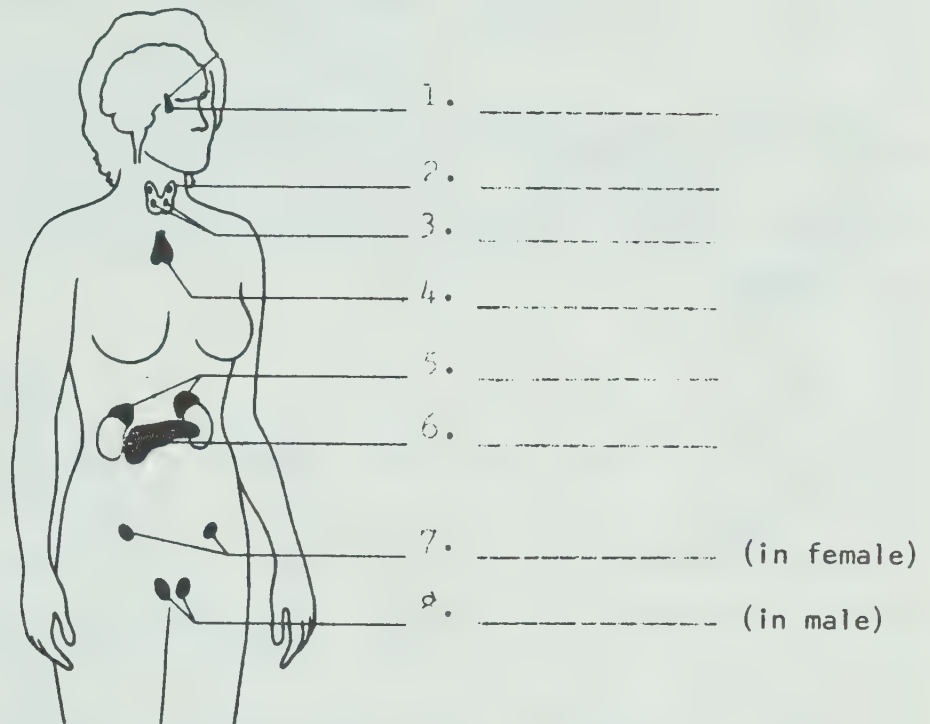
4. pigment found in the skin
5. hormone that stimulates milk production in the breasts
6. adrenalin affects this in the eye
10. the pituitary gland has two of these
11. a gland found over the larynx
12. these organs produce female hormones
15. glands that secrete into ducts
16. a female hormone
17. part of brain associated with the pituitary

DOWN

1. this hormone affects the size of the body
2. groups of secreting cells
3. this prefix means "inside"
7. a female hormone secreted by the ovary
8. a swelling in the neck due to a thyroid disorder
9. a disorder involving insulin
13. a chemical "messenger" in the blood
14. a hormone secreted by the pancreas

The Organs of the Endocrine System

Fill in the blanks with the correct labels.



Give the general function of each of the endocrine glands numbered above.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

ANSWERS TO SELF-TEST

- | | |
|-------|-------|
| 1. c) | 6. b) |
| 2. a) | 7. c) |
| 3. a) | 8. c) |
| 4. d) | 9. a) |
| 5. e) | |

ANSWERS TO CROSSWORD

ACROSS

- 4. melanin
- 5. prolactin
- 6. pupil
- 10. lobes
- 11. thyroid
- 12. ovaries
- 15. exocrine
- 16. estrogen
- 17. hypothalamus

DOWN

- 1. growth
- 2. glands
- 3. endo
- 7. progesterone
- 8. goitre
- 9. diabetes
- 13. hormone
- 14. insulin

LABEL ANSWERS FOR "THE ORGANS OF THE ENDOCRINE SYSTEM"
(Taken from Figure 17.1, text page 398)

- 1. pituitary gland
- 2. thyroid
- 3. parathyroids
- 4. thymus
- 5. adrenal glands
- 6. pancreas
- 7. ovaries (in female)
- 8. testes (in male)

GENERAL FUNCTIONS OF THE ENDOCRINE GLANDS

- 1. Pituitary: the master gland, controls or influences all the other endocrine glands.
- 2. Thyroid Gland: influences the metabolic rate, decreases blood calcium.

3. Parathyroid Glands: increase blood calcium.
4. Thymus: aids in immunity reactions in younger people.
5. Adrenal Glands: help to prepare the body for stress.
6. Pancreas: endocrine function is to control the blood sugar.
7. Ovaries: produce the female sex hormones; influence the secondary sex characteristics of the female.
8. Testes: produce the male sex hormones; influence the secondary sex characteristics of the male.

Selected Readings

1. Binkley, Sue, "A Timekeeping Enzyme in the Pineal Gland," *Scientific American* (April 1979).
2. Gillie, R. B., "Endemic Goitre," *Scientific American* (June 1971).
3. McClintic, Robert, *Basic Anatomy and Physiology of the Human Body*, 2nd ed. (New York: John Wiley & Sons, 1980).
4. Metter, Frank H., "Endocrine System and Selected Metabolic Diseases," CIBA Collection of Medical Illustrations, vol. 4. (Summit, N.J.: CIBA, 1965).
5. Notkins, Abner Louis, "The Causes of Diabetes," *Scientific American*, 1979.
6. Ratcliff, J. D., *Your Body and How It Works* (New York: Readers' Digest Press, 1975).
7. Riedman, Sarah R., *Hormones - How They Work* (New York: Abelard Schuman, 1973).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Glands and Hormones." 8 min col., Moreland-Latchford
2. "Discovery of Insulin." 18 min b&w, NFB
3. "Diabetes." From "The Nature of Things". 28 min col., NFB

FILMSTRIPS

1. "The Endocrine System." Visual Education Centre, Canada Ltd.

Unit X

Reproduction and Heredity

Chapter 18

Changes in the Reproductive System

Chapter Focus

In the simplest terms, this chapter focuses on the structure and function of the male and female reproductive systems and the menstrual cycle. However, the audience for these studies are young people, some of whom will already be sexually active. The students will have questions, and many of these will go outside the basic objective biological content and involve issues that are social and moral. Open discussion should be encouraged. Teachers have a responsibility to discuss these issues, but should not impose their own beliefs or views upon their students.

The focus of this chapter should, therefore, be to teach the structure and function of the reproductive systems in an open, questioning environment that will enable students to talk freely and ask questions about the topic within the context of their own experiences.

Objectives

After studying this chapter, the student should be able to .

- label a diagram of the male reproductive system
- identify and describe the organs of the male reproductive system
- explain the structure and function of the male reproductive organs
- describe the production of sperm and the detailed structure of a sperm cell
- describe the role of the accessory glands in the production of semen
- describe the structure and processes that enable erection to take place
- label a diagram of the female reproductive system
- describe the structures and functions of the female reproductive organs
- list and describe the functions of each of the four hormones involved in menstruation
- describe the changes that take place in the ovaries and uterus during menstruation
- define the term "feedback"
- know the structure and function of the mammary glands
- know the processes involved in copulation and fertilization
- list the major sexually transmitted diseases and state their symptoms

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
Changes in the Reproductive System		*
The Male Reproductive System	*	
The Testes	*	
The Production of Sperm	*	
The Ducts of the Male Reproductive System	*	
Accessory Structures	*	
The Penis	*	
The Female Reproductive System	*	
Puberty	*	
The Ovaries	*	
The Fallopian Tubes	*	
The Uterus		
The Endometrium and the Menstrual or Ovarian Cycle	*	
The Vagina	*	
The External Genital Organs	*	
The Mammary Glands	*	
Copulation and Fertilization		*
Menopause		*
Sexually Transmitted Diseases		optional

Teaching Suggestions

For some teachers, the topic of sexual reproduction poses some difficulties, especially during informal discussion sessions. If you feel uncomfortable with the subject matter and experience some personal inhibitions, then the following suggestions may be helpful.

- a) Consciously develop a comfortable environment for asking questions. This must be established at the very beginning of the course and maintained throughout. Students cannot be expected to talk freely about sexual topics unless the groundwork for questions has been well prepared in areas that are much less personal. Answer questions fully and honestly, and don't attempt to dodge the issue; students will spot the "cop-out" and you will quickly lose the credibility that you have worked so hard to gain.
- b) There is no need to be concerned about not knowing the answer to a question. Early in the course, as students ask questions about different disorders, refer to a comprehensive medical encyclopedia. Keep one handy in the classroom and ask a student to look up the answer and have the student read part of it to the class. You may then wish to comment upon it or explain further. Students accept that you do not profess to be all-knowing and respect you for it. When questions arise on subjects on which you are not well informed, tell the students that you will ask a medical source and get back to them. The local Medical Officer of Health, or his staff, are usually most co-operative.

- c) Make deliberate attempts to use humour. Nothing relieves tension and puts people at ease more quickly than laughter. Help students to recognize that sex can be funny at times without being in bad taste or offensive. Establish the boundaries of what is good taste and acceptable in the classroom, and what is not. If you feel secure, you can relate personal incidents in which humour arises. Let the students see you as "human"; this can also increase their respect for you.
- d) Establish a firm hold on terminology. Students will find it difficult to ask questions if they are hesitant about what words to use. Most students will not have spoken such words as "penis" or "vagina" out loud in the classroom, or in front of other people before, and some of them need encouragement to overcome their inhibitions. In the past, they may have used unacceptable descriptive terms with their friends, or familiar, vernacular terms within the family, some of which go back to early childhood. After the terms are initially introduced, a few quick Socratic questions, which require a one-word answer, help break the ice. Use a smile of encouragement and help out when necessary to relieve the pressure.
- e) From time to time, every teacher comes across a class in which questions are slow in coming. Other years the questions come so fast, it extends the topic and it is hard to maintain the course momentum. If you feel the students are inhibited, you can "feed" some questions. Use questions from other classes, or those raised in other years. Say that a student inquired about something after class and you think it is worth discussing with everyone. Talk openly and freely about it and let the students see that you can deal with very personal questions frankly and without embarrassment. Once rapport is established, the questions will quickly be generated by the class. Silence does not mean that they have no questions to ask.
- f) Do not allow personal standards to be too evident in your classroom technique. Let students see that you can be flexible and understanding, that you recognize that human weaknesses and strengths play very important roles in this area of study. Rigid moral standards inhibit questions. Never condemn a student for some action or activity that he or she has had the courage to ask about, even if it is in private. If you do not show some tolerance, or you set too high ideals, students will be reluctant to talk about some of the most important questions in their lives at this time of sexual awakening.
- g) Some teachers may feel that the biology class should confine itself strictly to anatomy and physiology and avoid the personal, moral, and social aspects of the subject. That, of course, is their prerogative. Nevertheless, there is no better place to talk about sexual activities and attitudes than in a human biology class, where the subject arises naturally and the students have been dealing on a very personal level with discussions about the human body since the start of the term.

The anatomy of the male and female rat, or another laboratory mammal, may be used for dissection to demonstrate the reproductive organs. Lennart Nilsson's *Behold Man* provides some excellent photography that is useful in this section. Solo Learn (see "Visual Aids") is another suitable source of slides and tapes.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 441)

- | | |
|-----------------|----------------------|
| 1. FSH | 6. Estrogen |
| 2. progesterone | 7. corpus cavernosum |
| 3. uterus | 8. prostate |
| 4. urethra | 9. testosterone |
| 5. endometrium | 10. seminiferous |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 442)

- The ducts through which the sperm passes are: seminiferous tubules, epididymis, vas deferens, ejaculatory duct, and urethra.
- The accessory glands provide nourishment for the sperm and supply an alkaline secretion that buffers the acid condition in the urethra caused by the passage of acidic urine. It also helps to neutralize the acid condition of the vagina. It aids in stimulating the mobility of the sperm and provides a medium in which the sperm can swim and be transported.
- Sertoli cells provide anchorage and nourishment for the developing sperm. Prostate gland: provides nutrients such as glucose. Contraction of this gland helps to push the semen out into the urethra during ejaculation. Its secretions help to neutralize the acid condition of the vagina and increase sperm motility.
Corpus cavernosum: these structures fill with blood during sexual excitement and cause the penis to become erect and firm.
Epididymis: a long, coiled tube in which the sperm continue to mature after leaving the testes.
- Some 400 000 ova, surrounded by a few follicle cells, are present in the ovary at birth. At puberty under the influence of FSH, the follicle continues its development, and the follicle cells increase in number and secrete estrogen. After about 14 days, the ovum is released from the ovary, while the remaining follicular cells form the corpus luteum. During the development of the ovum, it undergoes meiosis and the number of chromosomes is halved.

5.	Hormone	Organ where produced	Organ that hormone affects	General effect of the hormone
	progesterone	ovary	uterus	maintains endometrium
	estrogen	ovary	uterus	causes endometrium to thicken in preparation for the ovum
	FSH	pituitary	ovary	initiates the development of a new follicle
	LH	pituitary	ovary	stimulates release of ovum and development of the corpus luteum

6. The ovaries are found in the back of the abdominal cavity near the rim of the pelvis. They are held in place by the ovarian and suspensory ligaments.
7. Implantation: embedding of the fertilized ovum in the uterine lining.
Fertilization: the union of the sperm and ovum to form a single cell with the full number of chromosomes.
Ovulation: the release of the ovum from the ovary and its transfer into the fallopian tube.
8. Once mature and released from the ovaries or testes, the ovum and sperm are not directly connected to the body supply systems for oxygen and nutrients. Therefore, they can only live for a short period of time until their initial supplies of materials are used up.
9. The endometrium is the inner lining of the uterus. It has two layers. The deeper layer produces the replaceable cells of the inner layer which are lost during menstruation. The endometrium contains loosely associated epithelial cells, glands, and small capillaries.
10. Menstrual phase: the start of the menstrual flow and the gradual breaking up of the inner endometrial lining of the uterus.
Follicular phase: the release of FSH starts the development of a new follicle, the release of estrogen, and the replacement of the new lining of the endometrium.
Luteal phase: ovulation, development of the corpus luteum, the production of progesterone, and the maintenance of the endometrial lining of the uterus.

Text Activities

ACTIVITY 1: EXAMINATION OF REPRODUCTIVE TISSUES AND CELLS (TEXT, PAGE 443)

ACTIVITY OBJECTIVES

1. to practise microscope skills
2. to practise observation and drawing
3. to study the shape and structure of the reproductive tissues

PREPARATION TIPS

This material can be worked on individually by students, or as a teacher-directed examination of 2 x 2 slides using a projector.

Microscope slides can be quite easily photographed with a little practice and a duplicate projection slide is an invaluable aid in teaching any microscope work. Slide transparencies can be used to explain difficulties, to help students to identify specific and hard to find structures, for review, or, when time is short, as a direct substitute for microscopic examination.

METHOD 1

ANSWERS TO QUESTIONS

1. Gametes are haploid; other somatic cells are diploid.
2. The sperm first attach themselves to the Sertoli cells as maturation progresses.
3. Sertoli cells require large numbers of mitochondria to provide energy and nourishment for the sperm. They also anchor the sperm temporarily while it matures.
4. The cells produce testosterone.
5. The acrosome contains an enzyme that aids the sperm in its efforts to penetrate the ovum.

METHOD 2

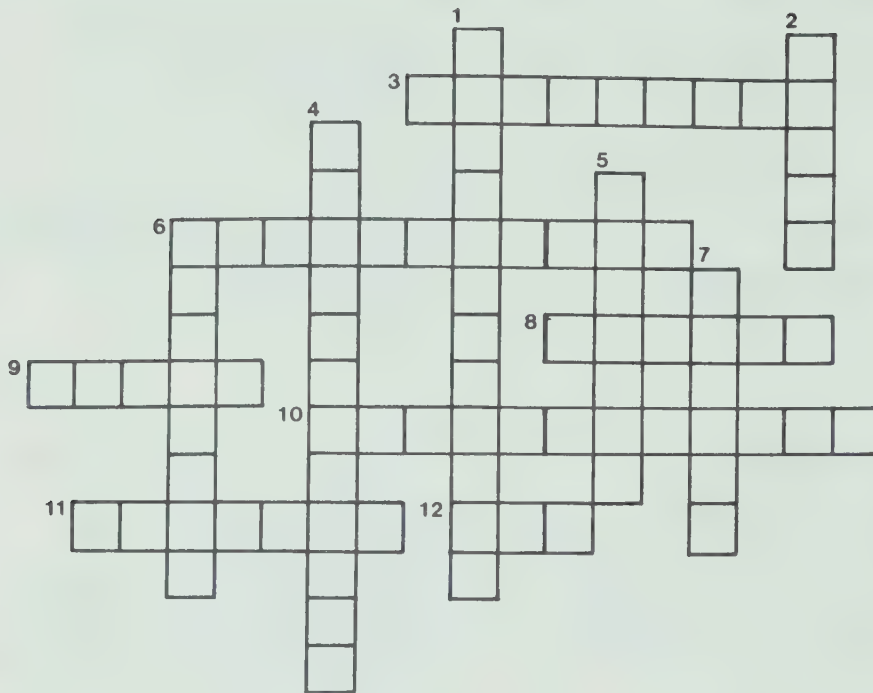
ANSWERS TO QUESTIONS

1. Follicle cells surround the ovum and produce follicular fluid and the hormones estrogen and progesterone.
2. The corpus luteum appears after ovulation. It is formed from the remaining follicular cells that at first produced estrogen. The corpus luteum produces progesterone when the follicular cells are influenced by the lutenizing hormone.
3. FSH: levels reach a peak just prior to ovulation.
LH: the level of this hormone is rising at this point but has not yet peaked.
Estrogen: high levels are produced; levels close to peak at ovulation.
Progesterone: relatively low levels, but rise after ovulation.

Self-test: Select the best answer

1. The primary sex organ in the female is the
 - a) uterus
 - b) vagina
 - c) ovary
 - d) ovum
2. The union of sperm and ovum usually takes place in the
 - a) ovary
 - b) Fallopian tube
 - c) uterus
 - d) vagina
3. The group of cells in the ovary which produces progesterone is the
 - a) corpus luteum
 - b) corpus albicans
 - c) corpus cavernosum
 - d) primary follicle
4. Which of the following does not carry sperm at any time?
 - a) urethra
 - b) epididymis
 - c) vas deferens
 - d) ureter
5. The release of the ovum from the ovary is known as
 - a) implantation
 - b) fertilization
 - c) ovulation
 - d) ejaculation
6. Sperm are produced in the
 - a) seminiferous tubules
 - b) cells of Sertoli
 - c) epididymis
 - d) vas deferens
7. The thickening of the uterine wall is mainly due to the influence of
 - a) estrogen
 - b) progesterone
 - c) FSH
 - d) LH
8. Semen is
 - a) a mixture of sperm and glandular secretions
 - b) a mixture of sperm and vaginal fluids
 - c) sperm and acid secretions from the prostate gland
 - d) a disorder of the reproductive organs
9. Large numbers of sperm are produced by the male in order to
 - a) ensure fertilization of the ovum
 - b) provide large amounts of an enzyme that enables sperm to enter the ovum
 - c) because many sperm are lost or do not reach the ovum.
 - d) All of the above are correct.
10. The testes are found in the scrotum outside the body
 - a) because there is not enough room inside the abdomen
 - b) because the temperature outside is cooler for the sperm to develop
 - c) because they are close to the penis
 - d) The reason for the testes being outside the body is not known.

Crossword



DOWN

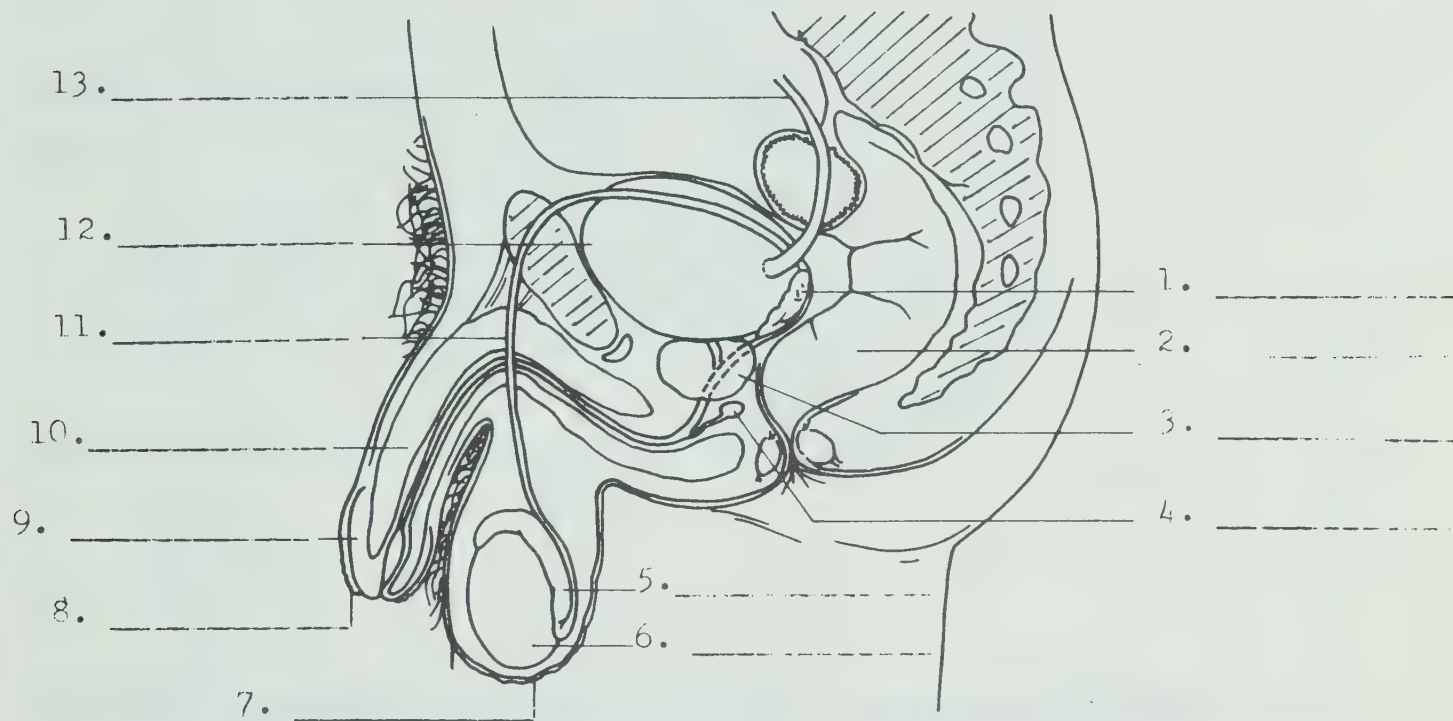
1. the regular discharge of the lining of the uterus
2. the male discharge containing sperm and glandular secretions
4. a female hormone that maintains the lining of the uterus
5. the point in the growth of an individual when sexual maturity is reached
6. a female hormone that influences the thickening of the uterine wall
7. a pear-shaped organ in which the fetus develops

ACROSS

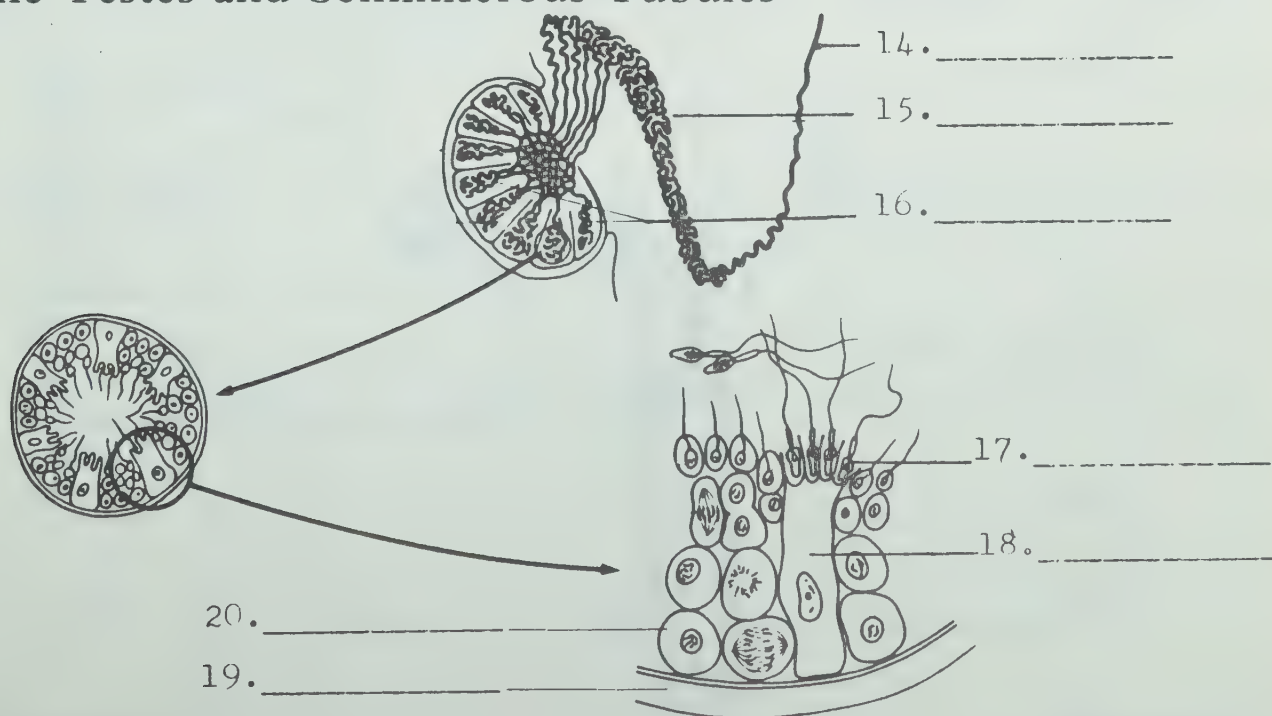
3. the time in the life of a woman when the ovaries cease to function
6. the lining of the uterus
8. the male gonads
9. where the ovum is produced
10. the major male hormone
11. a tube in the male that carries both urine and semen
12. human female gametes

Fill in the blanks with the correct labels.

The Structure of the Male Reproductive System

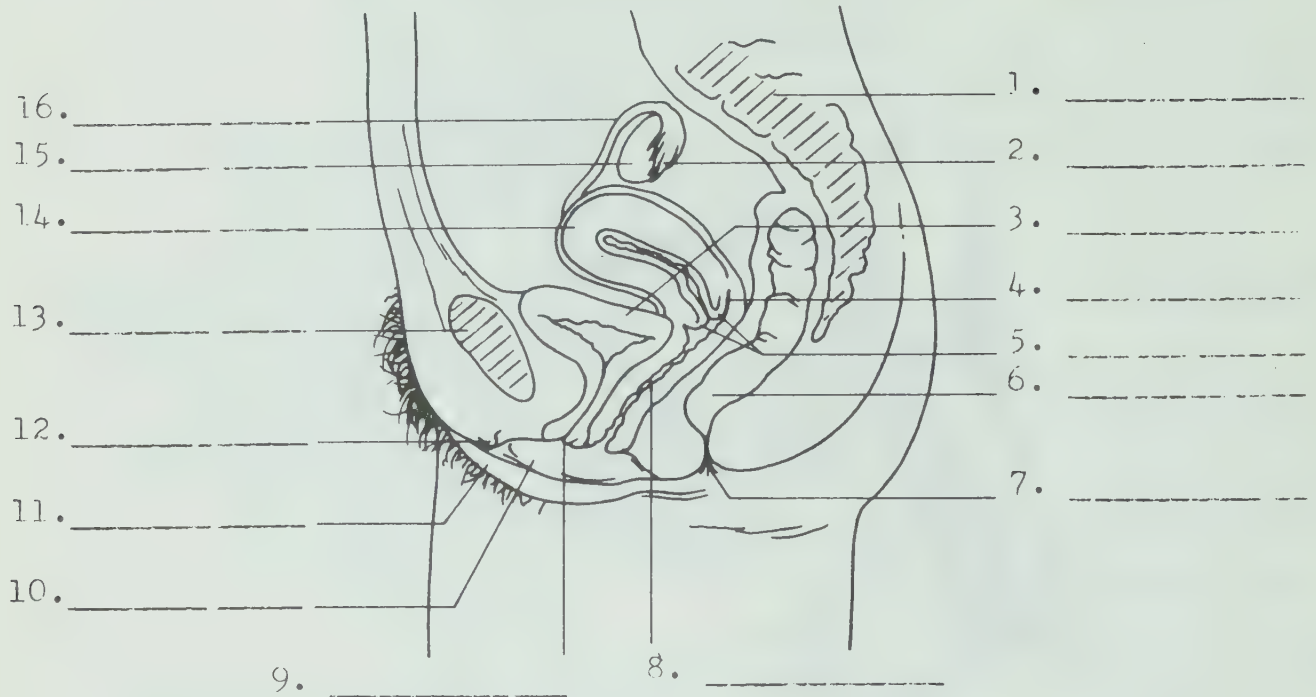


The Testes and Seminiferous Tubules

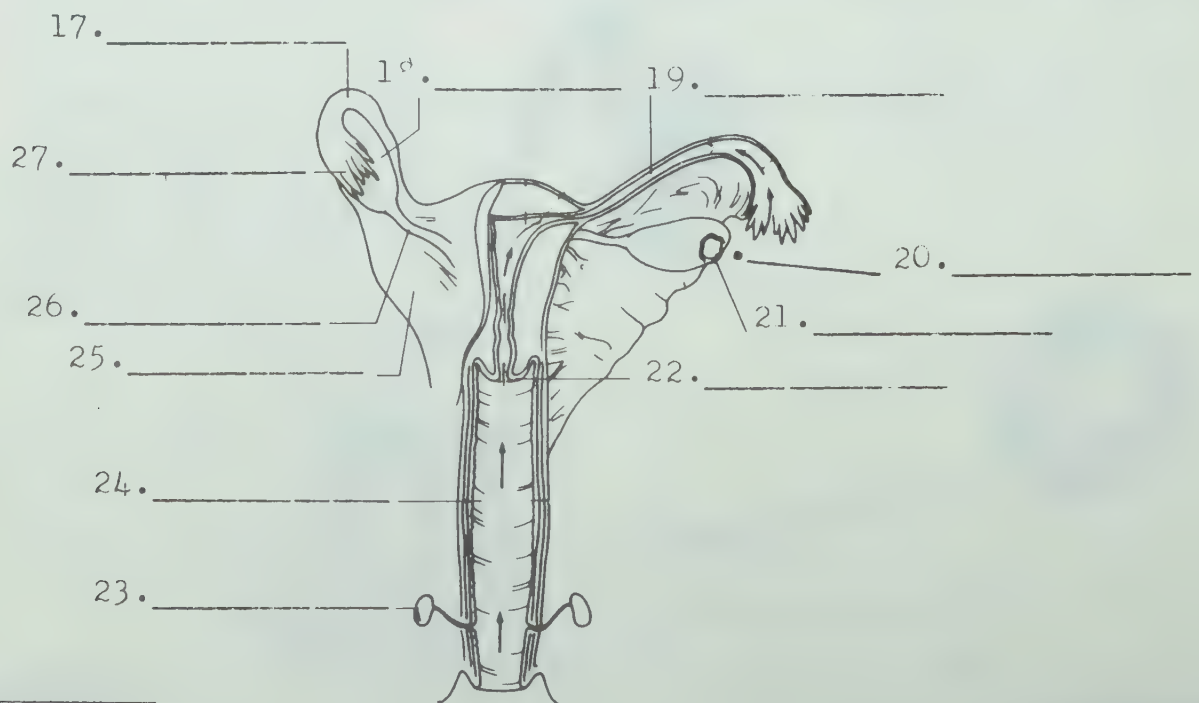


Fill in the blanks with the correct labels.

The Female Reproductive Organs



The Female Reproductive System and the Pathways of Sperm and Ovum



ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. c) | 6. a) |
| 2. b) | 7. b) |
| 3. a) | 8. a) |
| 4. d) | 9. d) |
| 5. c) | 10. b) |

ANSWERS TO CROSSWORD

DOWN

1. menstruation
2. semen
4. progesterone
5. puberty
6. estrogen
7. uterus

ACROSS

3. menopause
6. endometrium
8. testes
9. ovary
10. testosterone
11. urethra
12. ova

LABEL ANSWERS FOR "THE STRUCTURE OF THE MALE REPRODUCTIVE SYSTEM"
(Taken from Figure 18.1, text page 417)

1. seminal vesicle
2. rectum
3. prostate gland
4. Cowper's gland
5. epididymis
6. testis
7. scrotum
8. prepuce
9. glans
10. corpora cavernosa
11. ductus deferens (vas deferens)
12. bladder
13. ureter

LABEL ANSWERS FOR "THE TESTES AND SEMINIFEROUS TUBULES"
(Taken from Figure 18.2, text page 418)

14. vas deferens
15. epididymis
16. seminiferous tubules
17. maturing sperm held in Sertoli cell
18. Sertoli cell
19. wall of seminiferous tubule
20. germinal epithelial cells

LABEL ANSWERS FOR "THE FEMALE REPRODUCTIVE ORGANS"
(Taken from Figure 18.8, text page 425)

1. vertebral column
2. fimbrae
3. urinary bladder
4. fornix
5. cervix
6. rectum
7. anus
8. vagina
9. urethra
10. labium minora
11. labium majora
12. clitoris
13. pubic bone
14. uterus
15. ovary
16. Fallopian tube

LABEL ANSWERS FOR "THE FEMALE REPRODUCTIVE ORGANS AND THE PATHWAYS OF SPERM AND OVUM"
(Taken from Figure 18.9, text page 426)

17. Fallopian tube
18. ovary
19. Fallopian tube
20. ovum
21. follicle
22. cervix
23. Bartholin's gland
24. vagina
25. broad ligament
26. ovarian ligament
27. fimbrae

A SUMMARY OF CONTRACEPTIVE METHODS

METHOD	HOW SAFE IS IT?	HOW IT WORKS	WHO USES IT?	HOW IT IS USED	NEED FOR MEDICAL SERVICES	REASONS WHY IT MIGHT FAIL	COMMON SIDE EFFECTS
THE PILL	Excellent.	Prevents follicle from maturing. Inhibits ovulation.	F	Clear instructions on package. Must be regular. Best taken same time each day. Vitamin supplement required.	Yes, examination and prescription. Regular check-ups.	Forgetting to take pill. Not following instructions. Hormone content not high enough to suppress ovulation.	Irregular bleeding, spotting, nausea, weight gain, breast enlargement.
THE CONDOM (sheath, rubber)	Very safe especially with spermicide.	Prevents sperm entering the vagina. Provides some protection against S.T.D.'s	M	Placed on penis before intercourse. Condom must be held when penis is withdrawn to prevent it slipping off.	No.	Not put on before any contact with the vagina. Not sufficient care in removal.	None.
I.U.D. (coil, loop)	Very safe.	Prevents implantation.	F	Placed in uterus by doctor, remains in place. Copper coils must be replaced every 2 years. Lippe's loop can be left in indefinitely. Frequent checks required to ensure presence.	Yes, examination and insertion. Annual check-ups.	Some women do not retain the device.	Irregular bleeding, spotting, cramps. Discomfort in some cases.
DIAPHRAGM with jelly or creams	Safe if used with spermicide.	Prevents sperm from entering uterus. Jelly kills sperm.	F	Placed over cervix in vagina. Put in place before intercourse, removed 8 h later.	Yes, examination and prescription. Fitting instruction. Size will change if gain or loss of more than 5 kg.	Not correctly placed. Spermicide not used. Not left in place for 8 h after intercourse.	None.
CHEMICAL FOAMS (jellies, creams, foam tablets, and suppositories)	Fair, better than nothing. Foams better than the other products listed.	Kills sperm but some may escape. Blocks entry to uterus. Provides protection for one hour.	F	Place at the cervix in the vagina with special applicator. Insert not more than one hour before intercourse. Foams effective immediately; others wait 10 min before intercourse.	No.	May not completely block the cervix. Left too long, has lost its effectiveness. Some require waiting period. Douching before 8 h is up.	May cause irritation.
WITHDRAWAL	Very, very poor.	Penis ejaculates outside the vagina and away from it.	M	Withdrawal of penis just before ejaculation.	No.	Leaking of small amounts of semen at early stages of intercourse. Withdrawing too late.	None.
RHYTHM METHOD (The "safe" period)	Not safe.	Not having intercourse during part of the cycle when ovum is present in uterus.	Both	No sexual intercourse after the ovum leaves the ovary.	Medical help to determine cycle and the so called "safe" period	Dates are never exact. Variations in cycles. Variation in the time sperm and ovum stay alive.	None.
DOUCHE	Not safe.	Sperm is washed out of vagina after intercourse.	F	Vagina flushed out after intercourse.	No.	Sperm penetrate cervix. Douche may force sperm into uterus or fail to reach sperm. Sperm present in folds of vagina would be especially hard to reach	None.
STERILIZATION TUBAL LIGATION	Virtually 100%.	Part of tube from ovary to uterus removed. No follicle to fertilize.	F	Done in hospital under anaesthetic.	Yes.		A few days of recovery.
VASECTOMY	Virtually 100%.	Part of the tube from testis removed. Semen, but no sperm present.	M	Minor surgery in doctor's office.	Yes.		Temporary soreness of discomfort. Two sperm counts must be made before considered safe.

Sample of the type of form that is issued to a person suspected of having been in contact with a sexually transmitted disease. See case study on page 438 of the text.



Ministry
of
Health

Ontario

The Venereal Diseases Prevention Act

**NOTICE TO PERSON WHO IS OR MAY BE INFECTED OR HAS
BEEN EXPOSED TO INFECTION WITH VENEREAL DISEASE**

TO.....

OF.....

Under **The Venereal Diseases Prevention Act**, you are directed to submit to an examination by.....
(Name of physician) (Address of physician)

.....
.....
a physician within.....hours after receipt of this notice. You are further directed to procure and produce to me within..... after the examination a report or certificate of that physician that you are or are not infected with venereal disease, and, if so, in what form.

.....
(Signature of Medical Officer of Health)

for.....
(Name of municipality or health unit)

Date.....

2945-74 (2/77)

Selected Readings

1. Epel, D., "The Program of Fertilization," *Scientific American* (November 1977).
2. *Family Life and Health Encyclopaedia* (New York: Marshall Cavendish Corp., 1970).
3. Hyde, J. S., *Understanding Human Sexuality* (New York: McGraw-Hill, 1979).
4. Mayhew, Alice, "Our Bodies, Ourselves," (New York: Simon and Schuster, 1976).
5. Nilsson, Lennart, *Behold Man - A Photographic Journey inside the Human Body* (Boston: Little, Brown and Co., 1973).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Female Cycle." 7 min col., NFB
2. "About VD." 13 min col., NFB
3. "Sex and Reproduction." 18 min col., Calvin Films
4. "Masculine-Feminine." 18 min col., Coronet Films

35 mm SLIDES

1. "Human Reproductive Set." 40 slides. Carolina Biological

FILMSTRIPS

1. "The Reproductive System." With cassette. Wards Solo Learn. Arbor Scientific, Ont.

Chapter 19

Pregnancy and Birth

Chapter Focus

The purpose of this chapter is to provide an overview of the development of a single cell into a complex organism, first by multiplication of the initial cell, then by differentiation into many tissues and organs, until a complex integrated human being is produced. Parallel with this development is the description of the changes that take place in a mother's body. The teacher can provide a simple explanation of pregnancy and birth, and the important role that structures like the placenta play in pregnancy.

This chapter forms a natural bridge between the last chapter on reproduction and the concepts of heredity. The chapters are separated for organization and convenience, but should be presented as a continuous progression, rather than as completely separate topics.

Objectives

After studying this chapter, the student should be able to

- demonstrate a general understanding of the changes that take place in the fertilized cell during its development in the uterus
- describe the function of the amnion, yolk gland, and placenta
- explain the differences in fetal and adult blood circulation
- list the three germ tissues and give examples of the organs that develop from each tissue
- differentiate between an embryo and a fetus
- describe the general steps of birth and delivery
- list the functions of the placenta
- list the value of good nutrition during pregnancy and early childhood

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
Growth and Development		*
The Cell	*	
Early Development	*	
Pregnancy	*	
Structures within the Uterus	*	
Development of the Embryo and Fetus	*	
Birth	*	
Delivery	*	
Functions of the Placenta	*	
Twins		*
Differences in Growth between Boys and Girls		*
Nutrition and Growth		*

Teaching Suggestions

This chapter deals with a topic that always arouses tremendous interest among students and generates many questions. One of the main objectives should be to present the process of pregnancy and birth as a natural one and to allay the fears that many students have. Many of the questions that students ask concern the problems of delivery (breech births, Caesarean section, the pains of labour) or stories they have heard concerning especially difficult deliveries. Sometimes answering these questions seems to multiply the fears. Teachers should strive, even while answering questions honestly, to highlight the number of normal, healthy births. The birth of a baby must be presented as a very special event, one that can be anticipated with delight and excitement.

Teenage pregnancy is a very real problem in our society. One Canadian city in 1981 is reported to have had more births by unwed mothers than from married women. Among teenagers, the increasing number of unwanted pregnancies also tends to colour the attitudes of young people and contribute to a negative attitude about the event. Teachers can help to relieve the concerns of some of the students by an open and informed approach and by presenting the topics in a healthy, positive manner.

There is a definite need in the biology classroom for the teacher to depart from the prosaic, objective "structure-and-function" routine and help the students to recognize something of the wonder, awe, and beauty that exists in science. The birth of a baby is something to marvel at. The incredible changes that take place, as a single cell multiplies and differentiates into the complexity of a human being, are miraculous. The teacher has the opportunity to add a very special dimension to the learning process when topics such as this occur. To allow them to pass without comment denies the student some of the esthetic value that is equally as important as pure scientific knowledge.

Photographs are of enormous value in teaching this topic. Photographs from books or magazines that show the stages of the developing fetus may be presented on slides or on an opaque projector.

If you use mammals for dissection, order at least one pregnant cat or

rabbit. The structures of the placenta and uterus become instantly clear, and the tiny fetus with its attached umbilical cord creates special interest. If these fetuses are collected and preserved over several years, it is possible to complete a range of examples, from the early stages of development to animals ready to be delivered.

The delivery process is covered best by films. Be sure to preview the films for suitability for the age and level of the students in your class. Beware of films provided by special groups that have a particular viewpoint, such as anti-abortion groups. Regardless of whether you personally advocate their cause or not, the film material is usually biased, can lead to difficulties among students, and produce parental criticism. Good unbiased films are available and are preferable.

You may find that there are women on the teaching staff who have recently had a baby, and can talk with the students about the event. New parents, or nurses who conduct prenatal classes, are also excellent resource persons. These women can describe a first-hand experience and bring a freshness to the topic to which the students relate warmly.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 463)

- | | |
|-----------------|--------------------|
| 1. blastocyst | 6. ectoderm |
| 2. amnion | 7. gestation |
| 3. yolk sac | 8. umbilical cord |
| 4. embryo | 9. fraternal twins |
| 5. implantation | 10. implant |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 463)

1. Functions of the placenta:
Acts as a barrier between the blood system of the mother and the fetal blood system, which may be of a different blood type.
Passes nutrients and oxygen to the fetus.
Passes wastes and CO₂ from the fetus to the mother.
Acts as a barrier to bacteria.
Provides the fetus with immunity to diseases to which the mother has acquired immunity.
Prevents the mother from rejecting the fetus as "foreign material".
2. Fraternal twins develop from two different ova fertilized by two different sperm. They have different genetic endowments, just as brothers or sisters may have different genetic patterns. Identical twins develop from a single ovum fertilized by a single sperm. They thus share the same genetic characteristics and the same sex.
3. Ectoderm: nervous system, epidermis, salivary glands, pituitary gland, skin, hair, and nails.
Mesoderm: connective tissue, bone, blood vessels, spleen, and reproductive organs.

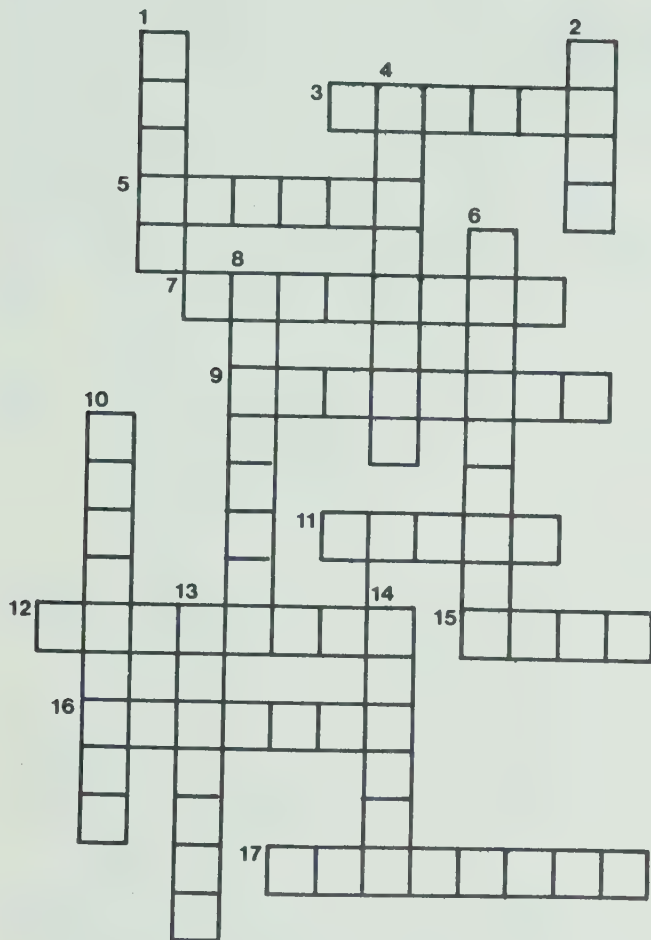
Endoderm: parts of the digestive tract, lining of the lungs and airways, liver, pancreas, and some endocrine glands.

4. Delivery is the second stage of labour and involves the entry of the baby into the outside world. The baby's head is positioned in the pelvis and enters the cervix. The body starts to rotate, and the head extends and is delivered first. First one shoulder passes and then the other follows. At this point, the widest portion of the baby, which stretches the birth canal the most, has passed and the rest of the body quickly follows. Shortly after the birth, the placenta is expelled.
5. Shocks that a baby experiences on entering the world:
Moving from a wet world into a dry one.
Changing from being dependent upon its mother for oxygen and nutrients to breathing on its own and starting to digest its own food.
Starting its own excretory process.
Changes in the heart and the closing of the foramen ovale, ductus venosus, and ductus arteriosus which now direct the full blood supply to the lungs and the liver.
Pressure from very strong muscular contractions as it passes through the birth canal.
6. Amnion: a thin, water-filled sac in which the embryo develops.
Implantation: the nesting action of the blastocyst into the endometrial wall. The yolk sac provides red blood cells for the embryo before the blood-forming tissues are ready to produce the baby's own red blood cells.
Labour: the period during which changes occur in the hormone levels in the mother's blood. These changes initiate the contractions of the uterus and the expelling of the fetus from the uterus.
7. (Repeat of question one.)
8. Good nutrition provides:
A store of materials from which the baby develops.
Body-building materials for rapid growth.
A wide variety of proteins to supply the many different needs of the body.
For special requirements, such as calcium for bones and teeth, in much greater proportion than is required at any other period in life.
The energy needed for rapid growth and active bodies.
9. Answers will vary. Some material is given in the following pages on implants.

Self-test: Select the best answer

1. The heart of a baby starts to beat
 - a) when a baby is born
 - b) about 18 d after conception
 - c) when it changes from an embryo to a fetus
 - d) about three months after the ovum is fertilized
2. After fertilization, rapid cell division occurs and a hollow ball of cells is implanted in the uterine wall. This ball is called
 - a) an embryo
 - b) a fetus
 - c) a blastocyst
 - d) a zygote
3. The term fetus is used when
 - a) the fetal heart starts to beat
 - b) when the feet start to develop
 - c) when the placenta is fully formed
 - d) when evidence of the first bone development is present
4. The hormone which prevents the uterus from contracting during pregnancy is
 - a) progesterone
 - b) estrogen
 - c) oxytocin
 - d) LH
5. Which of the following does not cross the placental barrier and enter the fetal blood stream?
 - a) nutrients
 - b) oxygen
 - c) blood cells
 - d) drugs and alcohol
6. Which of the following is not a true statement?
 - a) The umbilical cord carries two arteries and one vein.
 - b) Only the baby's blood is pumped through the umbilical cord.
 - c) Oxygen is carried in the umbilical vein.
 - d) If the cord is cut and not tied, the baby could bleed to death.
7. Which of the following do not apply during the first stage of labour?
 - a) irregular contractions of the uterus
 - b) dilation of the cervix and vagina
 - c) emergence of the head of the baby from the vagina
 - d) the breaking of the amniotic sac
8. The second stage of labour usually involves
 - a) the emergence of the baby from the vagina
 - b) rapid and forceful contractions
 - c) the assistance of the attending physician
 - d) All of the above.
9. Which of the following is not a true statement?
 - a) Genetics determine the potential growth ability of a child.
 - b) Nutrition determines if the necessary materials are present for the growth potential to be reached.
 - c) Heredity automatically controls height; if your father/mother was tall, you will be tall.
 - d) Genetics and nutrition are both factors in height determination.
10. Which of the following is not a true statement?
 - a) Girls usually learn to crawl, sit, and walk earlier than boys.
 - b) Girls usually start their main growth spurt earlier than boys.
 - c) Girls reach sexual maturity earlier than boys.
 - d) Boys acquire skills earlier and more rapidly than girls.

Crossword



DOWN

1. unborn baby; name used after first eight weeks of development
2. development of this structure signals change from fetus to embryo
4. middle germ layer of the embryo
6. condition when offspring is carried in the uterus
8. dividing of the fertilized ovum forming the blastocyst
10. vessels carrying nutrients to baby from the placenta and wastes from the baby to the placenta
13. process of producing an exact duplicate, many like cells from a single cell
14. a fetal membrane containing fluid and the fetus

ACROSS

3. name for baby during the first 8 weeks after conception
5. organ in which fetus develops
7. germ layer which gives rise to nervous system and epidermis
9. female hormone
11. two embryos developing at the same time
12. special organ that is later called the afterbirth
15. small sac that produces blood cells in early stages of development
16. outer membrane around the embryo; gives rise to the placenta
17. study of the gene complements within organisms

ANSWERS TO SELF-TEST

- | | | | |
|----|----|-----|----|
| 1. | b) | 6. | d) |
| 2. | c) | 7. | c) |
| 3. | d) | 8. | d) |
| 4. | a) | 9. | c) |
| 5. | c) | 10. | d) |

ANSWERS TO CROSSWORD

DOWN

1. fetus
2. bone
4. mesoderm
6. pregnancy
8. cleavage
10. umbilical
13. cloning
14. amnion

ACROSS

3. embryo
5. uterus
7. ectoderm
9. estrogen
11. twins
12. placenta
15. yolk
16. chorion
17. genetics

Additional Resource Material

THE FUTURE

During the past several decades, our medical techniques have advanced enormously. We are now in a highly technical age in which replacement parts, implants, transplants, and an enormous range of chemical and electronic products are aiding and extending the life of many individuals.

Previously, many disorders resulted either in death or severe curtailment of the individual's normal lifestyle. Medical advances have achieved important "cures" and produced tremendous hope for many sufferers.

Several categories of new knowledge have emerged:

1. Knowledge of the chemical workings of the body - drugs, artificial hormones.
2. Transfer of organs from donors to recipients - kidneys, parts of eyes.
3. Implanting of special devices to take the place of body organs that have failed - pacemakers, heart valves.
4. Devices to replace missing parts (prosthesis) - electronically operated hands and limbs.
5. Genetic knowledge and genetic engineering - amniocentesis, genetic counselling, etc.

Attempts to replace or repair body parts are not new; false teeth, wigs, wooden legs, glasses, glass eyes, metal plates to repair bones, etc. have been used, successfully in some cases, for centuries.

Artificial arms and hands are now made from metal and plastic and activated by small electric motors. Electrical activity in the muscles of the stump can, in some cases, be employed to operate parts of the new limb or hand. Plug-in attachments, knives, forks, grips, etc. make a wide variety of uses possible. It is now considered to be more appropriate to have attachments that are efficient rather than have them look normal but work less effectively.

When doctors try to place parts within the body, the materials used may affect the body and cause rejection of the implant. Materials have been developed that are chemically inert and do not react within the body or cause irritation. New joints for damaged limbs or to replace joints distorted by arthritis are now available. New cements have been discovered which will bind these artificial units to bone and allow new body cells to actually grow into the implanted materials.

Tubes of synthetic fibres can be used to replace weak or damaged blood vessels. Faulty valves in the heart can be replaced with a simple ball-and-wire cage device that permits one-way flow of blood inside the heart or blood vessels.

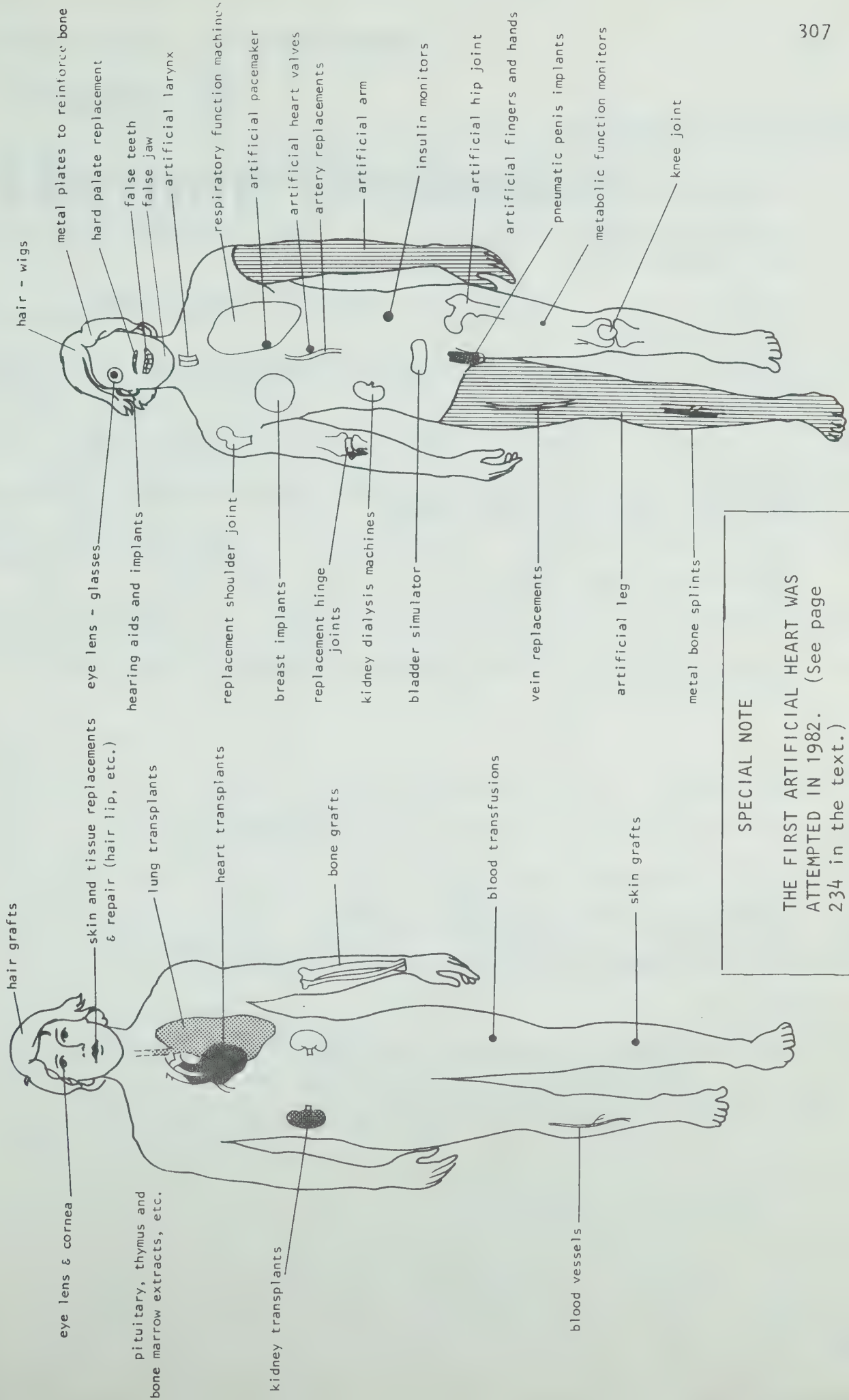
Electronic pacemakers with wires implanted into the muscles of the heart can replace the nervous control of the sinoatrial node. Such devices have been reduced in size and are now energized by minute batteries. These can be surgically implanted and left without attention for long periods of time. Complete artificial hearts are being developed and it is expected that these will be available in the near future.

Artificial kidneys which filter the blood are presently large and cumbersome machines, but they are a life-extending apparatus that can fill the gap until a suitable organ donor is available for the transplant of a complete kidney.

For many transplant operations, the chief difficulty is overcoming tissue rejection; that is, preventing the body from recognizing the implant as

foreign tissue and mustering all its forces to get rid of the vitally needed organ. The problem is slowly being resolved. As our understanding of the antigen-antibody relationship becomes more detailed, the success rate of organ transplants may increase considerably.

"Banks" of organs are now either available or being developed. In these storage systems, organs from dead persons can be kept "alive" until used by some person who needs them. Eye and sperm banks are already well established.



SPECIAL NOTE

THE FIRST ARTIFICIAL HEART WAS
ATTEMPTED IN 1982. (See page
234 in the text.)

Selected Readings

1. "Birth Control Handbook" and "VD Handbook" (1973) P. O. Box 1000, Station G, Montreal, P.Q. H2W 2N1.
2. Collegiate Minicourse Program. B.S.C.S. "Human Sexuality" (Philadelphia: W. B. Saunders, 1976).
3. Gordon, R. and A. G. Jacobson, "The Shaping of Tissues in Embryos," *Scientific American* (June 1978).
4. Heinmann, Brian B., *An Atlas of Embryology* (San Francisco: W. A. Freeman, 1975).
5. *Life before Birth* (New York: Cambridge University Press, 1978).
6. McClintic, Robert, *Basic Anatomy and Physiology of the Human Body* 2nd ed. (New York: John Wiley & Sons, 1980).
7. McKinnel, Robert, *Cloning: A Biologist Reports* (Minneapolis: University of Minnesota Press, 1979).
8. Moore, K. L., *Before We Are Born* (Philadelphia: W. B. Saunders Co., 1977).
9. Patten, B. M. and B. Carlson, *Foundations of Embryology* (New York: McGraw-Hill, 1974).

Visual Aids

For addresses of suppliers of visual aids, see Appendix B.

16 mm FILMS

1. "Pregnancy and Birth." 12 min col., NFB
2. "Fertilization and Development." 10 min col., Moreland-Latchford
3. "Chick Embryology." 12 min col., National Geographic

FILMSTRIPS

1. "Human Physiology: Embryology." With cassette. Carolina Biological

Chapter 20

Human Genetics

Chapter Focus

The main objective of this chapter is to explain how traits are transmitted from one generation to another by inheritance. Students are curious and ask many questions throughout the course about disorders or characteristics that they have inherited, or are concerned about inheriting, from their parents. These questions deserve an answer.

Students must have a basic understanding of the DNA molecule and how the sequence of nitrogen bases can encode information for transmission. The basic laws of inheritance are relatively simple to understand, and can be studied at whatever depth the teacher thinks appropriate, depending on the ability and interest of the students.

Once the students understand how inheritance is transmitted from one generation to another, an overview of some genetic disorders can be given and the important ideas, concerning genetic counselling and techniques for determining the presence of an abnormality, can be established.

Objectives

After studying this chapter, students should be able to

- describe the structure of a DNA molecule
- define "chromosome" and "gene"
- explain what is meant by the genetic code
- define the terms "homologous", "heterozygous", and "homozygous"
- draw and describe the steps involved in meiosis
- demonstrate how inheritance works by solving problems involving dominant and recessive genes
- further explain the transmission of traits by solving problems in incomplete dominance, sex-linkage, and the use of pedigrees
- define the terms "phenotype" and "genotype"
- solve problems using multiple genes
- explain sex determination
- define the term "mutation" and list the major mutagenic agents
- describe how birth defects can be diagnosed, how parents can benefit from genetic counselling, and how birth defects can be reduced
- explain trisomy

Topic Priorities

TOPICS	of Major Importance	of Minor Importance
What are Chromosomes?	*	
The Genetic Code	*	
Meiosis	*	
Inheritance	*	
How Genes Act	*	
The Transmission of Genes	*	
Incomplete Dominance and Co-Dominance		*
Pedigrees	*	
Multiple Genes	*	
Sex Determination	*	
Sex-Linkage		*
Mutations		*
Birth Defects		*
Genetic Factors		*
Environmental Factors		*

Teaching Suggestions

Some students will probably have covered part of the material in this chapter in earlier biology courses. However, the emphasis here is on human genetics, and the examples and problems are specific to humans.

To make this text useful for both general and advanced levels, some concessions had to be made. Thus, a fairly low profile has been given to the chemical processes. With advanced level students, teachers may wish to develop the concept of the chromosome in greater detail. An understanding of the DNA molecule and its role in protein synthesis is most valuable. If students understand how the sequence of nitrogen bases in a DNA molecule eventually determines the sequence of the amino acids that form a particular protein, then they can quickly comprehend how genetic information is stored in the chromosomes and how it can be transmitted to the offspring. It is worth taking time to consolidate this understanding before advancing to the general laws of genetics.

Meiosis can be taught by chalkboard development and drawings, and is readily consolidated by use of one of the excellent films available. This concept is fundamental to understanding the independent assortment of chromosomes, which will be introduced later.

The "chance" element that is present in inheritance can be easily demonstrated by a simple exercise using coins. Each student has a coin and flips it 20 times. Each pair of students flips at the same time as his or her partner and records the results.

	Head/Tail	Tail/Tail	Head/Head
trial 1			
trial 2			

The results for each pair are totalled under each heading and expressed as a percentage of the total number of flips. The results of the whole class are then totalled and expressed as a percentage. The teacher can then quickly establish that it is a matter of chance as to which pair comes together, and that a small sample is less predictable than a large sample. This exercise can also be used to show the chances of a trait occurring by recessive or dominant genes, or to demonstrate sex inheritance by substituting "X" for heads and "Y" for tails.

It is important to consolidate the inheritance of single traits before progressing to the inheritance of two traits. It is necessary to give students many examples to reinforce the methods and terms involved.

There seems to be some confusion and inconsistency among genetics texts about the exact interpretation of incomplete dominance and co-dominance. As far as I can determine, incomplete dominance refers to the appearance of a new intermediate characteristic that has not been present before. Its use seems to be more common in plant genetics, i.e., a cross between a white flower and a red flower may result in a pink flower. Co-dominance is more commonly used when a heterozygous condition produces the same trait but in a less severe form, i.e., sickle-cell anemia in the heterozygous patient produces a milder and non-fatal condition of the same disease.

Students enjoy the pedigrees and can be encouraged to develop a pedigree for traits that appear in their own family. Teachers should be wary of setting assignments that are too specific, as some students have only a few relatives, or perhaps no access to their biological parents (adoption cases).

Good overhead projectors are a valuable asset in this part of the course. Teachers may wish to develop their own acetates, rather than take time developing chalkboard drawings each year. Often such overheads are more useful than professional purchased samples, because they fit the technique and approach of the teacher more effectively.

Some teachers may wish to digress, when talking about mutations, and discuss some of the problems associated with nuclear energy and nuclear wastes. There are some very important ecological and social issues that can be covered here. Man does not live in isolation from the environment, and hazards from nuclear radiation sources are rapidly increasing. The numbers of birth defects attributed to chemical, nuclear, and radiation hazards have increased dramatically in recent years, and teachers may wish to elaborate on this point, or ask students to research news items.

Teachers should check with their provincial listings for information on genetic counselling. Free information is available on subjects such as amniocentesis, Down Syndrome, etc. The Carolina Biological Company provides a wide variety of useful material that teachers can use for activities. See "Visual Aids" for some recommended films.

Questions for Review

ANSWERS TO SOME WORDS TO KNOW (TEXT, PAGE 494)

- | | |
|-----------------|------------------|
| 1. heterozygous | 6. mutation |
| 2. phenotype | 7. trisomy |
| 3. gene | 8. meiosis |
| 4. chromosomes | 9. amniocentesis |
| 5. homologous | 10. haploid |

ANSWERS TO SOME FACTS TO KNOW (TEXT, PAGE 494)

1. The chromosome is a molecule of deoxyribonucleic acid. It is composed of two chains of alternating sugar and phosphate molecules, linked together by pairs of nitrogen bases. Adenine is paired with thymine, cytosine is paired with guanine. Protein molecules are also found within the chromosome.
2.
 - a) Meiosis is the process by which a germinal cell, with a full complement of chromosomes, divides and produces two cells, each with half the number of chromosomes, one of each homologous pair. The resulting sex cells differ genetically in characteristics.
 - b) There are 23 pairs of chromosomes in each body cell, 22 pairs of autosomes and one pair of sex chromosomes.
 - c) The gametes have half the number of chromosomes that somatic cells have (23 chromosomes in all).
3.
 - a) The term homozygous is used to recognize pairs of chromosomes that carry the same trait information. Heterozygous refers to pairs of chromosomes that carry information for differing expressions of the same trait.
 - b) Homologous chromosomes are pairs of chromosomes, of similar shape and size, that carry the same kind of genes in the same order.
4. Skin colour is determined by a number of genes; different combinations produce many variations. Not all the characteristics are based on strictly dominant and recessive laws; therefore intermediate conditions, as in incomplete dominance, are possible.
5. Sex is determined by whether the sperm that fertilizes a particular egg contains an X or a Y chromosome. Ova fertilized by Y chromosomes will be males; ova fertilized by sperm carrying X chromosomes will produce females.
6. Mutations represent a permanent change in a gene, which results in an inheritable characteristic. The offspring will produce a trait that is not present in the parents. Mutations can be caused by slight alterations in the DNA produced by spontaneous genetic mutations or by environmental factors such as viruses, drugs, radiation, or diet.
7.
 - a) some causes of birth defects are mutations, environmental factors (such as chemical hazards and radiation), poor health habits of the mother (such as the use of drugs and alcohol), and the inheritance of genetic disorders.
 - b) The risk of birth defects can be reduced by good health care, and maintaining a reasonable body weight and good nutrition. If a risk is known to be present by inheritable transmission, genetic counselling and tests such as amniocentesis can be used. Inoculation against such infections as german measles and desensitization of Rh factors are other preventative measures. Prenatal care and avoiding alcohol, smoking, and drugs contribute substantially to the chances of having a healthy baby.
8. Amniocentesis can help to identify chromosomal abnormalities and biochemical substances that indicate a baby has some birth defect before

a baby is born. With this knowledge, parents can make a decision to terminate the pregnancy, if they wish to do so. (See page 450 of the text for further explanation.)

9. Inherited diseases are transmitted by the chromosomes from one generation to another. Congenital defects are not inherited, but arise as the result of an infection during pregnancy or by some event during delivery. Dietary deficiencies may also result in congenital disorders.
10. Answers will vary.

ANSWERS TO PROBLEMS IN GENETICS (TEXT, PAGE 495)

1. ♀ Cataracts are dominant C homozygous CC
♂ normal sight recessive c homozygous cc

Cross CC x cc

		C	C	♀
♂	c	Cc	Cc	
	c	Cc	Cc	

Predicted phenotypes

100% with cataracts

Predicted genotypes

100% heterozygous cataracts

2. Curly hair is dominant. Straight hair is recessive.

♀ curly hair Cc or CC
♂ straight hair cc

Children

		C	c	♀
♂	c	Cc	cc	
	c	Cc	cc	

		C	C	♀
♂	c	Cc	Cc	
	c	Cc	Cc	

Predicted phenotypes

50% curly hair

50% straight hair

Predicted genotypes

50% heterozygous curly

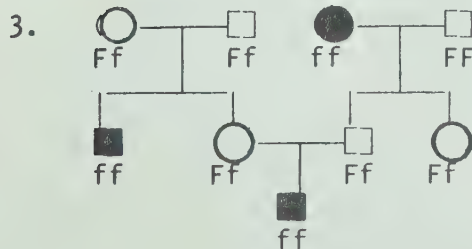
50% homozygous straight

OR predicted phenotypes

100% curly hair

predicted genotypes

100% heterozygous curly.



Let farsightedness be f
normal sight F

If trait is recessive shaded symbols have ff homozygous. Unshaded symbols will have at least one capital letter for the dominant gene.

The trait is recessive.

4. a) Phenylketonuria is likely to be recessive as it appears to skip alternate generations. Dominant genes appear in each generation.
- b) In cousin marriages there is a greater chance of the gene appearing, as the gene is already known to be in the family inheritance. This is a more restricted gene pool and provides a greater chance for the gene to be expressed.

5. The man has inherited one "O" gene from each parent (they must be heterozygous). The man with O blood is homozygous as the trait is recessive.

Cross OO x AB

		A	B
♂ O		AO	BO
♀ O		AO	BO

50% of children with B blood type
(heterozygous)

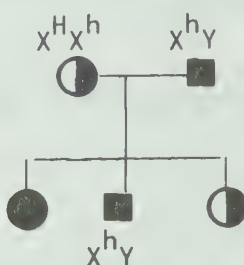
6. Male AB Female OO Child AB

		A	B
♂ AB		AO	BO
♀ OO		AO	BO

Children of such a cross must be either A or B blood type. The mother may donate either an A or B but not both. One of the genes must be inherited from the father. This male cannot be the father.

7. Hemophilia is normally transmitted by a carrier mother and the gene is expressed in the son.

Mother $X^H X^h$
Son $X^h Y$



X^H normal gene
 X^h hemophilia gene

The gene for hemophilia is carried on the larger X chromosome and is not present on the shorter Y chromosome. The father must transmit the Y to a son and therefore does not transmit the hemophilia gene. However, if the mother carried a hemophilia gene as well as the father, then the son and the daughter could both be hemophiliac.

- b) Hemophiliac women must be homozygous for the trait ($X^h X^h$). As the mother can contribute only an X gene and the father a Y, the son will lack the trait and have the disease. (If the male is hemophiliac and the female is a carrier, then there would be a 50% chance of producing a hemophiliac daughter.)

Text Activities

ACTIVITY 1: THE ABILITY TO TASTE PTC (TEXT, PAGE 496)

ACTIVITY OBJECTIVES

1. to show that all people have the same abilities; homozygous recessive individuals are unable to detect PTC
2. to offer an opportunity for students to determine inheritance within their own families
3. to practise dominant and recessive characteristics problems
4. to practise the preparation of a pedigree

PREPARATION TIPS

PTC paper can be purchased from a supply house, or it can be prepared in the school laboratory. Solutions vary in strength and it is usually necessary to prepare a dilution series in order to obtain the proper strength. Dip strips of filter paper into the solution and allow to dry.

ACTIVITY 2: IS THE ABILITY TO ROLL THE TONGUE INHERITED? (TEXT, PAGE 496)

ACTIVITY OBJECTIVES

1. to practise the preparation of a pedigree
2. to practise dominance and recessive characteristics problems
3. to provide an involvement in a genetics problem

ANSWERS TO QUESTIONS

1. Answers will vary.
2. The ability to roll the tongue is dominant.
3. The genotypes of rollers may be homozygous or heterozygous. The genotype of non-rollers is homozygous recessive.
4. Yes. If both parents were heterozygous for the dominant trait of tongue rollers, they could both transmit recessive genes to their offspring and produce a non-roller.

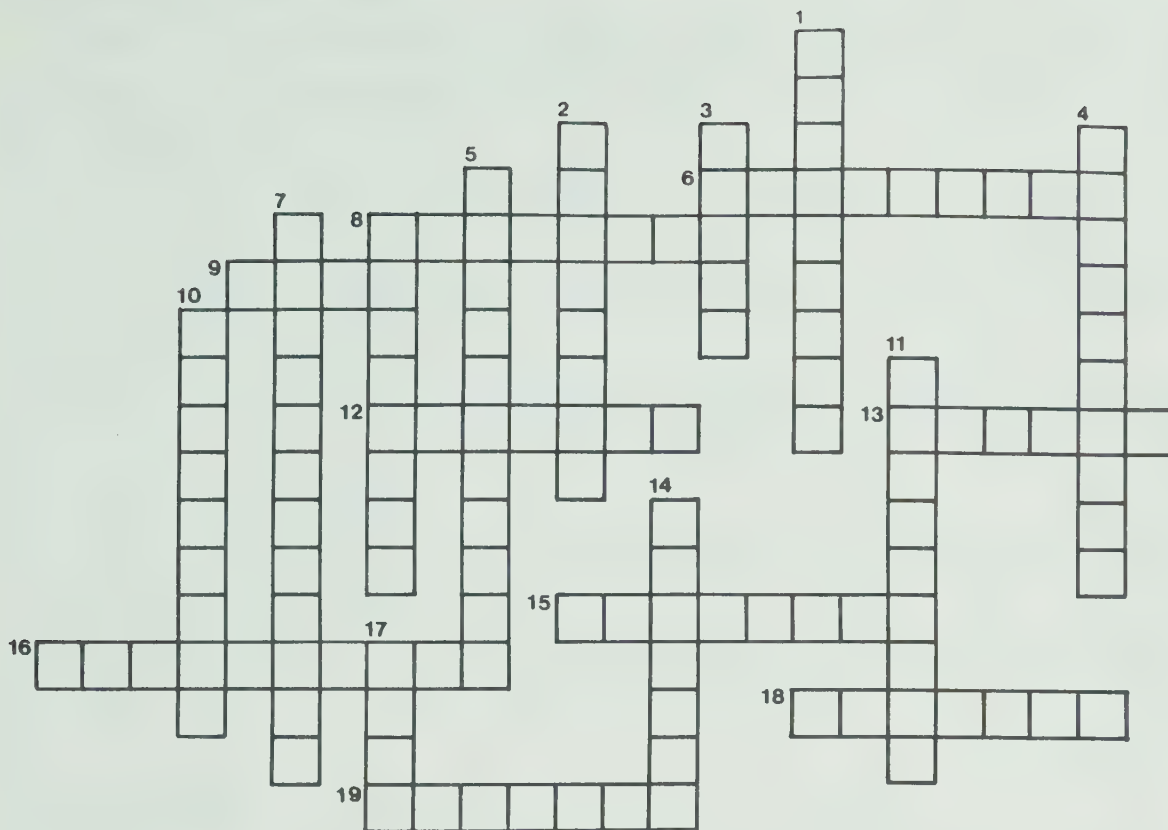
Example: $\begin{matrix} \text{♂} & & \text{♀} \\ Tt & \times & Tt \end{matrix}$

	T	t
T	TT	Tt
t	Tt	tt

Self-test: Select the best answer

1. In humans, normal body cells contain
 - a) 46 chromosomes
 - b) 23 chromosomes
 - c) 23 pairs of chromosomes plus two sex chromosomes
 - d) 23 pairs plus one sex chromosome
2. The term genotype refers to the
 - a) visible characteristics
 - b) hidden characteristics
 - c) chromosome composition
 - d) chromosome composition and the visible characteristics
3. Chromosomes contain sequences of different
 - a) amino acids
 - b) nitrogen bases
 - c) sugars
 - d) fatty acids
4. In a DNA molecule adenine always pairs with
 - a) cytosine
 - b) guanine
 - c) thymine
 - d) None of the above.
5. A homozygous pair of genes
 - a) carry the same genetic information about a characteristic
 - b) carry two different pieces of information about a characteristic
 - c) contain hidden carrier information about a trait
 - d) are found only in females
6. In a heterozygous pair of genes for a particular trait
 - a) both genes are dominant
 - b) two recessive genes are present
 - c) a dominant and recessive gene are present
 - d) either two dominant or two recessive genes are present
7. If an individual, homozygous for a dominant trait, mates with a person with homozygous recessive genes for the same trait, the offspring will
 - a) all show the dominant characteristic
 - b) appear in the ratio of 3:1 dominant to recessive
 - c) show 50% dominant and 50% recessive characteristics
 - d) all express the recessive trait
8. In sex-linked traits
 - a) the X chromosome usually carries the gene involved
 - b) the gene is lacking in the Y chromosome
 - c) girls usually are carriers of the trait
 - d) All of the above are correct.
9. Which of the following statements is not correct?
 - a) Mutations may be caused by radiation.
 - b) At present mutations cannot be cured.
 - c) Mutations are not transmitted to the offspring.
 - d) Mutations happen by chance.
10. Which of the following statements is not a correct answer? Sickle cell anemia is a genetically inherited disease that
 - a) results in the formation of an abnormal kind of hemoglobin
 - b) causes the formation of distorted red blood cells
 - c) is caused by a change in the sequence of one of the bases in the DNA chain
 - d) causes the same problems for carriers as for afflicted persons

Crossword



DOWN

1. a gene that is not expressed when a dominant trait is present
2. a permanent change in the gene
3. male gamete
4. sex-linked hereditary blood disorder
5. the transfer of characteristics or traits from one generation to the next
7. pair of dissimilar genes
8. the study of the genes and inheritance patterns
10. cause of many mutations
11. a mapping of the human chromosomes based on shape and size
14. sex cells
17. female sex cell

ACROSS

6. the visible expression of traits in an individual
8. the gene complement of an individual
9. short section of a chromosome responsible for a characteristic
12. the presence of an extra chromosome in addition to the homologous pair
13. blood disorder when red blood cells are few in number
15. gene that is expressed in the phenotype even when a recessive gene is present
16. chain of nitrogen bases carrying the genetic plan
18. condition when only half the chromosomes are present
19. process of cell division when the chromosomes are not doubled

HANDOUT

ANSWERS TO SELF-TEST

- | | |
|-------|--------|
| 1. a) | 6. c) |
| 2. c) | 7. a) |
| 3. b) | 8. d) |
| 4. c) | 9. c) |
| 5. a) | 10. d) |

ANSWERS TO CROSSWORD

DOWN

- 1. recessive
- 2. mutation
- 3. sperm
- 4. hemophilia
- 5. inheritance
- 7. heterozygous
- 8. genetics
- 10. radiation
- 11. karyotype
- 14. gametes
- 17. ovum

ACROSS

- 6. phenotype
- 8. genotype
- 9. gene
- 12. trisomy
- 13. anemia
- 15. dominant
- 16. chromosome
- 18. haploid
- 19. meiosis

Selected Readings

1. Baver, William R. *et al.*, "Supercoiled DNA," *Scientific American* (July 1980).
2. Croce, C. M. and H. Koprowski, "The Genetics of Human Cancer," *Scientific American* (February 1978).
3. Crow, J. F., "Genes That Violate Mendel's Rules," *Scientific American* (February 1979).
4. Eigen, Manfred *et al.*, "The Origin of Genetic Information," *Scientific American* (April 1980).
5. Fuchs, Fritz, "Genetic Amniocentesis," *Scientific American* (June 1980).
6. "Genetics," Collegiate Minicourse Program. B.S.C.S. (Philadelphia: W. B. Saunders, 1976).
7. McKusick, Victor A., "The Mapping of Human Chromosomes," *Scientific American* (April 1971).
8. Mirsky, Alfred E., "The Discovery of DNA," *Scientific American* (June 1968).

Visual Aids

16 mm FILMS

1. "Gene Action." 16 min col., EBE
2. "The Laws of Heredity." 15 min col., EBE
3. "Bionics: Man or Machine." 24 min col., EBE

FILMSTRIPS

1. "Cellular Inheritance."
 2. "Genetic Inheritance."
 3. "Directed Inheritance."
- With cassette. International Tele-Film Enterprises Ltd., Canada

APPENDIX A. PREPARING SOLUTIONS

ACETIC ACID

Add 5.69 mL of concentrated acetic acid to 1 L of distilled water. The concentration is 0.1 M.

BENEDICT'S SOLUTION

This solution can be purchased ready-made or can be prepared as follows:

Dissolve 173 g of sodium or potassium citrate and 200 g of sodium carbonate in about 600 mL distilled water. Filter. Dissolve 17 g of copper sulphate in 100 mL water. Add distilled water to make 1 L of solution.

BIURET REAGENT

This solution can be purchased ready-made or can be prepared as follows:

Dissolve 2.5 g of copper sulphate in 1 L of water. Dissolve 440 g of sodium hydroxide in water to make up 1 L of solution. Before using, add 25 mL of copper sulphate to 1 L of sodium hydroxide.

BUFFER SOLUTIONS (pH)

These can be purchased ready-made. Prepare stock solutions of 0.1 M citric acid by dissolving 19.2 g and make up to 1000 mL with distilled water. Prepare a stock solution of 0.2 M disodium phosphate by adding 28.4 g to 1000 mL of distilled water.

For the desired pH, mix the correct amounts as indicated:

<u>pH</u>	<u>citric acid (mL)</u>	<u>disodium phosphate (mL)</u>
3.0	15.9	4.1
4.0	12.3	7.7
6.0	7.4	12.6
7.0	3.5	16.5
8.0	0.6	19.5

HYDROCHLORIC ACID

For Activity 1, page 112 of the text, to prepare the hydrochloric acid concentration, add 50 mL of concentrated HCl to 450 mL of water.

IODINE SOLUTION

Dissolve 10 g of potassium iodide in 100 mL of distilled water. Then add 5 g of iodine. To prepare a 0.01 mol/L iodine solution, add 2.54 g of iodine crystals in 25 mL of 95% ethyl alcohol and dilute to 1000 mL with distilled water.

LIMEWATER

To distilled water, add an excess of calcium hydroxide or calcium oxide. Shake well and let stand for 24 h. Pour off the supernatant fluid and keep. Limewater should be clear.

METHYLENE BLUE

Dissolve 1.5 g of methylene blue in 100 mL 95% ethyl alcohol. For use, add 10 mL of this solution to 90 mL distilled water.

MILLON'S REAGENT

Dissolve 100 g of mercury in 200 mL of concentrated nitric acid in a fume cupboard. Dilute with 300 mL of distilled water.

QUININE SOLUTION

Dissolve 0.72 g of quinine sulphate in 100 mL of distilled water to make a 0.1% solution. Quinine solution may also be purchased in any pharmacy.

SODIUM CARBONATE

To prepare 1 M Na_2CO_3 dissolve 106 g and bring volume to 1000 mL with distilled water.

APPENDIX B. DIRECTORY OF BIOLOGICAL SUPPLIERS AND VISUAL AIDS

Arbor Scientific Co. Ltd.
1840 Mattawa Avenue
Mississauga, Ontario
L4X 1K1

Boreal Laboratories
1820 Mattawa Avenue
Mississauga, Ontario
L4X 1K6

Calvin Communications
1105 Truman Road
Kansas City, MO 64108
USA

Carolina Biological Supply Co.
Burlington, N. Carolina 27215

or

Powell Laboratories Div.
Glastone, Oregon 972027
USA

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Gordon Watt Film Inc.
3241 Kennedy Rd.
Unit #3,
Scarborough, Ontario
M1V 2J8

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Don Mills, Ontario
M3A 1A4

Informedia Productions
Marlin Motion Pictures Ltd.
Suite 1212
666 St. James Street
Winnipeg, Manitoba
R3G 3J6

or

211 Watline Avenue
Mississauga, Ontario
L4Z 1P3

International Tele-Film Enterprises Ltd.
See Pyramid Films

Media and Technical Services
Box 1800
University of Victoria
Victoria, B.C., V3W 2Y3

Moreland-Latchford
See Pyramid Films

National Film Board
(see separate listing)

National Geographic Society
National Geographic Educational Service
151 Carlingview Drive, Unit #5
Rexdale, Ontario
M9W 5S4

or

Box 2895
Washington, D.C. 20013
USA

Northwest Laboratories Ltd.
P. O. Box 1356
Guelph, Ontario
N1H 6N8

or

3581 Shelbourne Street
P. O. Box 6100
Station C
Victoria, B.C.
V8P 5L4

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133 Manville Rd.
Unit #19
Scarborough, Ontario
M1L 4J7

Pyramid Films
R. Bury Media and Supplier Ltd.
2305 W. King Edward Avenue
Vancouver, B.C.
V6L 1T3

Sargent-Welch Co.
Check Provincial Listings
Head Office: 285 Garyray Drive
Weston, Ontario
M0L 1P3

Viking Film Ltd.
Unit #9
151 Esna Park Dr.
Markham, Ontario
L3R 3B1

Visual Education Centre
John Walker Ltd.
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or

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Calgary, Alberta T2P 3C3

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(403)231-5414 (film
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Edmonton, Alberta T5J 0G9

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(306)569-5012 (film
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366 Oxford Street East

London, Ontario N6A 1V7

Telephone: (519)679-4120

195 First Avenue West

North Bay, Ontario P1B 3B8

Telephone: (705)472-4740

910 Victoria Avenue

Thunder Bay, Ontario P7C 1B4

Telephone: (807)623-5224

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(514)283-4685 (film library)

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library)

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(819)375-5811 (film
library)

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Telephone: (902)426-6000

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Sydney, Nova Scotia B1P 5K8
Telephone: (902)562-1171

Terminal Plaza Building
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(506)858-2943 (French production)

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Saint John, New Brunswick E2L 1E7
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202 Richmond Street
Charlottetown, P.E.I. C1A 1J2
Telephone: (902)892-6612

Building 255
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St. John's, Newfoundland A1A 1N3
Telephone: (709)737-5005

4 Herald Avenue
Corner Brook, Newfoundland A2W 6C3
Telephone: (709)634-4295

APPENDIX C. LITERATURE AND FILM LOANS AVAILABLE FREE OF CHARGE

FREE LITERATURE is available from the following organizations: (check with your local telephone directory for your provincial numbers.)

Canadian Arthritis and Rheumatism Society
Canadian Cancer Society
Christmas Seal Society
Heart Foundation
Kidney Foundation of Canada
The Lung Foundation
Muscular Dystrophy Assn. of Canada
Red Cross Canadian

FREE LOAN FILMS are available from the following organizations: (check with your local telephone directory for your provincial numbers.)

Canadian Arthritis and Rheumatism Society
Canadian Cancer Society
National Film Board

APPENDIX D. SUGGESTED LIST OF EQUIPMENT

BASIC LABORATORY EQUIPMENT

compound microscopes (set)
 dissection microscopes (set)
 glass slides
 coverslips
 eye droppers
 beakers 50 mL
 beakers 250 mL
 10 mL pipettes
 flasks 250 mL
 glass cover plates
 test tubes 10 mL
 test tubes 25 mL
 scalpels
 tweezers
 probes
 dissection trays
 hemolet lancets
 blood-typing kits
 Rh blood-typing kits
 Talquist scale booklets
 sterile Petri dishes
 disposable inoculating loops
 Bunsen burners
 alcohol lamps
 antibiotic discs
 hotplates
 tape measures
 wax marking pencils

HUMAN BIOLOGY EQUIPMENT

skeleton
 knee joint
 heart model
 bone sections
 eye model
 ear model
 human model
 bathroom scales
 reflex hammer
 pulse meter (audible)
 Sphygmomanometers
 stethoscopes
 sterilizer
 incubating oven
 smoking apparatus (Eduquip)
 skin calipers
 thermometers
 penlights

spirometer
 colour blindness charts (Ishara)
 eye chart (Snellen)
 astigmatism chart

CHEMICAL SUPPLIES

Bromothymol blue indicator
 Benedict's solution
 methylene blue
 Millon's reagent
 Biuret reagent
 Wright's blood stain
 phenolphthalein
 iodine solution
 alcohol (70%)
 agar
 beef extract
 pepsin
 pancreatin
 lysol*
 limewater
 diastase
 lipase
 glucose
 lactose
 sucrose
 starch (soluble)
 corn syrup*
 vegetable oil*
 brown sugar*
 olive oil*
 gelatin*
 PTC paper
 *can be purchased locally

PREPARED GLASS SLIDES

blood smear
 bone tissue
 3 types of muscle
 epithelium 3 types
 adipose tissue
 human sperm
 ova
 Graffian follicle

MISCELLANEOUS SUPPLIES

toothpicks

pins

thread

dividers (mathematical)

rulers (clear plastic)

rubber stamp 2.5 cm^2 divided into 100 small squares

stamp pad

small paint brushes

scotch tape

masking tape

Q-tips

J-cloths

straws

kleenex

combistix

page 18/ Column 2/ line 7
0.2 mm *should read* 0.2 nm

Smooth Muscle

page 48/ Left-Hand Column/ Heading

/ between "Cardiac muscle" and "Blood"

Add the main heading **CONNECTIVE TISSUE**

page 50/ Table 2.2

Third box down should read Muscular

Then this system should include

Skeletal muscles. Body movement.
 heat production.

Next system is Circulatory

This system then includes

blood, heart, blood vessels	Transports nutrients, wastes, gases, circulates the blood.
--------------------------------	---

page 51/ Table 2.2 (cont'd)

Second box down should read Respiratory

Then this system should include

Nose, throat, larynx, trachea, lungs.	Exchange of oxygen and carbon dioxide.
---------------------------------------	--

Next system is Digestive

Then this system should include

Mouth, esophagus, stomach, liver, pancreas, intestines.	Breakdown and absorption of nutrients, excretion of wastes.
---	---

page 119/ line 7

Figure 5.2 shows how these markings appear under a microscope.

should read Figure 5.4 shows how these markings appear under a microscope.

page 131/ Activity 4/ Part 1/ Line 1

Look at Figure 5.8 to discover the points of origin . . . *should read*

Look at Figure 5.11 to discover the points of origin . . .

page 143/ Figure 6.7/ 4th label down on left-hand side

hypothalmus *should read* hypothalamus

page 182/ Figure 7.5

Light should approach from the bottom of the diagram, NOT the top

page 279/ Table 12.1/ last line/ Column 2

300 000 000 000 *should read* 300 000 000

(Three hundred million, not three hundred thousand million)

page 318/ Figure 13.13/ TOP LEFT label

3-5 min *should read* 3-5 h

page 347/ Materials/ first line

25-mL test tubes, Sudan IV brown paper *should read* 25-mL test tubes, Sudan IV, brown paper

page 363/ Activity 1

Activity 1: Introduction *should read* Activity 1: EATING FOR ENERGY

page 381/ Figure 16.3, The Nephron

1. the "proximal convoluted tubule" should point to the WHITE tube inside the red one (not the red one).

2. the label "efferent arteriole" on the vessel leading to the glomerulus *should read* "afferent arteriole"

page 467/ Figure 20.1 The Watson-Crick model of the DNA molecule.

The DR pentagons on the *right* are correct. The pentagons on the *left* are incorrect. They should be changed to be MIRROR IMAGES OF THE ONES ON THE RIGHT.

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